

***United States Court of Appeals
for the
District of Columbia Circuit***



**TRANSCRIPT OF
RECORD**

APPENDIX TO BRIEF FOR APPELLANT

IN THE
United States Court of Appeals
FOR THE DISTRICT OF COLUMBIA.

JANUARY TERM, 1942.

No. 8310.

SINCLAIR REFINING COMPANY

v.

CONWAY P. COE, Commissioner of Patents,

Appellee.

Appeal from the District Court of the United States
for the District of Columbia

Filed June 4, 1942.

RAYMOND F. ADAMS,
LOUIS D. FORWARD,
CLARENCE M. FISHER,
Attorneys for Appellant.

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APPENDIX TO BRIEF FOR APPELLANT

1 IN THE DISTRICT COURT OF THE
 UNITED STATES

FOR THE DISTRICT OF COLUMBIA.

CIVIL ACTION No. 7884.

SINCLAIR REFINING COMPANY, 630 Fifth Avenue,
New York, New York,

Plaintiff,

vs.

CONWAY P. COE, Commissioner of Patents,
Washington, D. C.,

Defendant.

Bill of Complaint

Complaint for Issuance of United States Letters Patent.

I. The jurisdiction of this Court depends upon the Patent Laws of the United States, this Complaint being filed under Section 4915, Revised Statutes (Comp. Stats. 9460; U. S. C. Title 35, Section 63), as amended by Act of March 2, 1927.

II. The plaintiff, Sinclair Refining Company, a Corporation duly organized and existing under and by virtue of the laws of the State of Maine, is by an assignment in

writing, executed on the 2nd day of March, 1938, and duly recorded in the United States Patent Office on the 9th day of March, 1938, in Liber E174, Page 538, of the Transfers of Patents, the sole owner of the entire right, title and interest in an application for United States Letters Patent of Reading B. Smith, for improvements in Conversion of Petroleum, filed in the United States Patent Office on March 9, 1938, Serial No. 194,776, and the improvements disclosed and claimed therein.

2 III. The Board of Appeals of the United States Patent Office has refused to allow two claims of said Reading B. Smith application, Serial No. 194,776, which claims are as follows:

1. The process for conversion of higher boiling petroleum oils to lower boiling oils which comprises heating the higher boiling oil to vaporize it and thereafter to crack it, maintaining a pressure exceeding the critical pressure on the oil through the point of vaporization and heating the oil prior to vaporization at a rate high enough to prevent substantial decomposition prior to vaporization.

2. The process for conversion of higher boiling petroleum oils to lower boiling oils which comprises heating the higher boiling oil to its critical temperature and thereafter to crack it, maintaining a pressure exceeding the critical pressure on the oil through the point at which it attains its critical temperature and heating the oil prior to this point at a rate high enough to prevent substantial decomposition prior to this point.

IV. The defendant, Conway P. Coe, Commissioner of Patents of the United States, by the aforesaid decision of the Board of Appeals of the United States Patent Office

has refused and still refuses to grant Letters Patent of the United States to the plaintiff, Sinclair Refining Company, as assignee of said Reading B. Smith, on his said application, Serial No. 194,776, including said two claims recited in Paragraph III hereof.

V. The said decision of the Board of Appeals was rendered on or about the 25th day of March, 1940, and within six months last past, and no appeal has been taken from said decision of the Board of Appeals to the Court of Customs and Patent Appeals, and no such appeal is pending or has been decided.

3 WHEREFORE, the plaintiff, Sinclair Refining Company, demands that this Honorable Court authorize the Commissioner of Patents to issue to plaintiff, Sinclair Refining Company, Letters Patent of the United States embodying said claims 1 and 2 upon the filing in the United States Patent Office of a certified copy of such adjudication, and upon compliance with the requirement of the law for such cases made and approved.

SINCLAIR REFINING COMPANY,

By CLARENCE M. FISHER,
CLARENCE M. FISHER,
Attorney for Plaintiff,
National Press Building,
Washington, D. C.

RAYMOND F. ADAMS,
of Counsel.

4 IN THE DISTRICT COURT OF THE
UNITED STATES

FOR THE DISTRICT OF COLUMBIA.

CIVIL ACTION No. 7884.

SINCLAIR REFINING COMPANY,

Plaintiff,

v.

CONWAY P. COE, Commissioner of Patents,

Defendant.

W. W. COCHRAN,
Solicitor, U. S. Patent Office,
Attorney for Defendant.

Answer to the Complaint

*To the Honorable the Justices of the District Court of
the United States for the District of Columbia:*

I, II, III. Defendant admits the allegations of paragraphs I, II and III.

IV. He admits that he has refused and still refuses to issue to plaintiff a patent containing claims 1 and 2 of application No. 194,776, of Reading B. Smith. He denies that such refusal is wrongful or that plaintiff is lawfully entitled to a patent containing said claims since these claims are deemed to be unpatentable over the following

prior patents and publication and for the reasons given in the statement of the examiner in answer to the appeal and the decision of the Board of Appeals, copies of which will be presented at the trial:

Gard	1,914,914	June 20, 1933
Peck	1,933,507	Oct. 31, 1933
McKee "Critical Temp. and Oil Cracking";		
Ind. and Eng. Chem.; Vol. 20, No. 11; Nov. 1928;		
pp. 1169-1172.		

5 Profert of copies of these patents and publication is hereby made.

V. He admits the allegations of paragraph V.

W. W. COCHRAN,
Solicitor, U. S. Patent Office,
Attorney for Defendant.

September 23, 1940.

I hereby certify that a copy of this Answer was mailed to the attorney for plaintiff on September 23, 1940.

W. W. COCHRAN,
Solicitor.

6 **Memorandum for Clerk**

Judgment for defendant.

April 14, 1942

(S) McGUIRE.

Findings of Fact

1. This is an action under Section 4915 R. S. (U. S. C., title 35, sec. 63) in which plaintiff, the assignee of a patent application of Reading B. Smith, seeks to have the Court authorize the Commissioner of Patents to issue to plaintiff a patent containing claims 1 and 2 of the application.

2. The application, No. 194,776, was filed in the Patent Office on March 9, 1938, and relates to the conversion of petroleum, that is, to the cracking of hydrocarbons of relatively high boiling point, such as gas oil, to produce hydrocarbons of lower boiling point, such as gasoline. It is stated that by the claimed process the oil may be cracked without substantial formation of pitch.

3. The process is set forth in claim 1 as follows:

1. The process for conversion of higher boiling petroleum oils to lower boiling oils which comprises heating the higher boiling oil to vaporize it and thereafter to crack it, maintaining a pressure exceeding the critical pressure on the oil through the point of vaporization and heating the oil prior to vaporization at a rate high enough to prevent substantial decomposition prior to vaporization.

4. The patent to Gard, No. 1,914,914, of June 20, 1933, discloses a method of cracking oil, in which deposits of carbon are eliminated. In the disclosed method the oil is heated to its cracking temperature, which is described as being above the critical temperature of the oil, while subjected to a pressure which is above the critical pressure. The heated oil is released into a low pressure coil where it vaporizes instantly. The vapors are heated in this coil to crack them in the vapor phase. This patent

states that in heating the oil to the cracking temperature, the oil is heated rapidly.

5. The Peck patent, No. 1,933,507, of October 31, 1933, relates to the cracking of hydrocarbon oils under conditions that, according to the patent, will preclude separation of the oil and vapor phases of different compositions during the time the oil is heated up to cracking temperature. The stated object of the invention is to diminish greatly the deposition of coke. In the method disclosed in this patent the oil is heated to a temperature above the critical temperature while under a pressure above the critical pressure. It is stated in the patent that the rate of heating is sufficiently high to insure a homogeneous state of the oil.

6. The Howard et al. patent No. 1,869,337, of July 26, 1932, discloses a process of cracking heavier hydrocarbon oils to reduce their viscosity and to form low boiling point oils, in which method the heavier oil is initially heated in a coil at a rate described as rapid to a temperature of 725°-750° F., which is below the critical temperature, while under a pressure sufficient to maintain the oil substantially entirely in the liquid phase. After the recited initial rapid heating, the oil passes into a second coil where it is further heated mildly to bring about the cracking thereof. It is stated in the patent that by this process the production of coke is materially reduced or even substantially eliminated.

7. The article "Critical Temperatures and Oil Cracking", by McKee and Parker, which was published in November, 1928, sets forth the results of the authors' investigations of the boiling points, specific gravities, and critical temperatures of various hydrocarbon oils.

8. The prior patents to Gard and Peck show that long before plaintiff's application was filed it was well known

that in cracking oil by heating it, the deposition of coke or carbon could be minimized or prevented by heating the oil rapidly to a temperature above the critical temperature while it is under a pressure above the critical. In view of disclosures made in these patents and in the Howard et al. patent, it was not invention to adopt the same procedure to obviate or minimize the formation of pitch.

9. The rate of heating the oil as recited in claims 1 and 2 here in issue differs only in degree, if at all, from the rates described as rapid in the prior art and was not a patentable variation of the prior art.

10. Nothing recited in plaintiff's claims 1 and 2 amounts to an invention over the prior art, and neither of these claims is patentable.

10

CONCLUSIONS OF LAW.

1. Plaintiff is not entitled to the issuance of a patent containing either of claims 1 and 2 of the Smith application No. 194,776.

2. The Complaint should be dismissed with costs against the plaintiff.

MATTHEW F. McGUIRE,
Justice.

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Judgment

This cause having come on to be heard and having been tried in open court and argued by counsel for the respective parties upon the pleadings and proofs adduced and submitted to the Court,

It is ADJUDGED this 6th day of May, 1942, that the complaint in this case be, and the same hereby is dismissed with costs against the plaintiff.

(S) JUSTICE McGUIRE,
Justice.

Approved as to form:

CLARENCE M. FISHER,
Attorney for Plaintiff.

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Notice of Appeal

Notice is hereby given that Sinclair Refining Company, Plaintiff above named, appeals to the United States Court of Appeals for the District of Columbia from the final judgment entered in this action on May 6th, 1942.

CLARENCE M. FISHER,
CLARENCE M. FISHER,
Attorney for Sinclair Refining Company,
834 National Press Building,
Washington, D. C.

June 3rd, 1942.

Copy to:

W. W. COCHRAN,
Solicitor, United States Patent Office,
Washington, D. C.

17 IN THE DISTRICT COURT OF THE
UNITED STATES

FOR THE DISTRICT OF COLUMBIA.

CIVIL ACTION No. 7884.

SINCLAIR REFINING COMPANY,

Plaintiff,

v.

CONWAY P. COE, Commissioner of Patents,

Defendant.

Washington, D. C.,
Wednesday, March 4, 1942.

The above-entitled cause came on for trial before Associate Justice Matthew F. McGuire, in Civil Division No. 5, at 10 o'clock a. m.

APPEARANCES:

On behalf of the plaintiff: C. M. FISHER, LOUIS D. FORWARD.
On behalf of the defendant: W. W. COCHRAN, Solicitor,
U. S. Patent Office.

Proceedings

Mr. Fisher: If your Honor please, I should like to ask permission for Mr. Louis D. Forward, a member of the Bar of the courts of New York, to try this case on behalf of the plaintiff.

The Court: That may be done.

OPENING STATEMENT ON BEHALF OF
THE PLAINTIFF.

Mr. Forward: If your Honor please, this is the usual type of complaint for issuance of letters patent, brought on behalf of the assignee of a patent application which was filed in the name of Reading B. Smith, serial No. 194776. That was acted upon by the Examiner, a rather cursory examination, and in my opinion the Examiner completely misunderstood it, from the nature of the action he took, but he did reject it. An appeal was taken to the Board of Appeals, and the Board of Appeals affirmed the Examiner. This action has been brought for the reason, and I think we can make it quite clear when the process is once thoroughly understood, that the action of the Board of Appeals was based upon a misconception. They still failed to appreciate just what it was that the inventor claimed and what the identity was of the invention that had been made, and what we were trying to claim.

The subject matter of this invention relates to an oil cracking process, a type of process where you take high-boiling distillate oils, such as gas oil, and heat them under decomposing temperatures so that they crack and make gasoline. It is a gasoline-making process.

There are three general classes, broad classes, of oil cracking process over a period of years that have been extensively used commercially. Of course there
19 have been many minor modifications of each of those, but in the broad classifications are first what might be characterized as the pressure distillation process where a large bulk of oil is heated under pressure very slowly and it distills off at about 2% an hour, thus making gasoline that way.

The second general class, I would say, is what is referred to as the tube and tank process. There are quite a number of those, the outstanding ones being those of Cross, Dubbs, Holms, Manley, and the like. They heat

the oil up in a coil. Instead of heating a big boilerful of it they heat the oil up in a coil and then pass it over into an unheated chamber, and the chamber and the coil are all maintained under the same pressure, and there your reaction proceeds. The coil is heated relatively mildly, but rapidly in comparison to what took place in the old bulk still heating or bulk still cracking process.

The most recently adopted cracking process that has gone into extensive commercial use is what I am going to characterize as high-pressure coil cracking typified by the so-called Winkler-Koch process that has made such inroads on the oil cracking industry that it has been the subject of a large number of patent suits, all of which have been in vain. That process is characterized by a long coil—a very long coil—and you do all your cracking in the coil under very high pressure. The oil is heated up quite rapidly to the temperature at which you are going to crack, and then it goes through a soaking section. When it comes out of the coil the pressure is reduced and there is no further cracking, at least no significant further cracking.

The bane of this industry from the very beginning, a tremendous bane in the earlier process, was the
20 formation of carbon and tar, particularly the formation of carbon. Both carbon and tar form as a by-product of the cracking reaction. Usually they form progressively. The tar is formed first, and that further decomposes into this coke that tends to deposit on the heating surfaces of the still and to cause or form an insulating layer which made a lot of trouble and caused them to terminate operation and clean out the carbon.

This Winkler-Koch type high-pressure coil process did a great deal to solve the carbon problem. In other words, whereas the earlier processes could only operate a few days or perhaps at most a few weeks without stopping to clean out the carbon, this Winkler-Koch type of process will operate for a period of months and then only have a small carbon deposit, but it still does form a large amount

of tar. They have prevented that tar from decomposing further into carbon to any substantial extent, as carbon is formed to only a very minor extent.

This applicant discovered, by sheer accident, that if he maintained the pressure on the coil above the critical pressure of the oil and heated the oil initially as it was first put in—initially heated the oil at such a high rate to its critical temperature, that is, the point at which it vaporizes regardless of pressure—the vaporization was instantaneous and complete, and that thereafter he could continue to crack, and the cracking reaction operated entirely differently, because this tar, which had previously been a by-product of all cracking reactions theretofore practiced, was no longer formed as a by-product of the cracking reaction, and you just formed the gasoline without this undesirable tar, which was a very cheap and undesirable by-product.

21 And that is the sum and substance of the invention. It consists in merely heating an oil under a pressure in excess of its critical pressure at such an excessively rapid rate that it gets to a temperature above its critical temperature before it has a chance for any significant or anything more than a trace of decomposition to occur, and then, having vaporized it, proceeding to crack it. I think the claim is embodied in this (handing a document to the Court).

The Assistant Clerk: Do you want it marked?

Mr. Cochran: No.

Mr. Forward: That is going to be his exhibit.

A typical claim is in the application or is included in the bill of complaint on page 2, and I think claim 1 will be illustrative. Claim 2 is merely a different phraseology of the same thing, to be certain that we have it correctly defined one way or the other. Claim 1 reads as follows:

“The process for conversion of higher boiling petroleum oils to lower boiling oils—”

That is the object.

“—which comprises heating the higher boiling oil to vaporize it and thereafter to crack it, maintaining a pressure exceeding the critical pressure on the oil through the point of vaporization and heating the oil prior to vaporization at a rate high enough to prevent substantial decomposition prior to vaporization.”

Now, in the patents on which we were rejected in the Patent Office those inventors had the idea of heating an oil under a high pressure above its critical pressure, to a temperature above its critical temperature. In other words, they were above both the critical pressure and
22 the critical temperature, but they failed to appreciate the one important feature, and that is the necessity of this extreme rapidity of heating; and unless you have that extreme rapidity of heating, as we want to try to show your Honor, you do not get the result.

OPENING STATEMENT ON BEHALF OF THE DEFENDANT.

Mr. Cochran: May it please your Honor, it seems from Mr. Forward's opening statement that the real essence of the alleged invention is the very rapid heating of the oil prior to vaporization—so rapid that there shall be no decomposition, or substantially no decomposition, of the oil during that initial rapid heating.

Mr. Forward: That is the essence, but it has to be under those rules, at pressure above the critical pressure and go to a temperature above the critical temperature.

Mr. Cochran: Yes, but I understood that that is shown in the prior art. That is, the heating of the oil to above the critical temperature and under a pressure above the critical pressure—that is shown, but the real novelty here, if any, would be in the rapidity of that heating.

Mr. Forward: That is right.

Mr. Cochran: The heating being so rapid as to not allow decomposition of the oil during that period of heating.

The patents which were relied on by the Board of Appeals not only show the heating of oil to a temperature above the critical temperature, at a pressure above the critical pressure, but do mention that the heating is done rapidly, and the statement is made in at least one of those

23 patents that the purpose is or that by heating it rapidly there will be a less formation of coke or carbon.

Now, the position of the Patent Office is that the applicant here has not done anything substantially different from what is shown in those patents.

EVIDENCE ON BEHALF OF THE PLAINTIFF.

Mr. Forward: I should like to call Mr. Reading B. Smith as a witness on behalf of the plaintiff.

Thereupon READING BARLOW SMITH was called as a witness for and on behalf of the plaintiff and, having been first duly sworn, was examined and testified as follows:

Direct Examination:

The Assistant Clerk: And your full name?

The Witness: Reading Barlow Smith.

Mr. Forward: I should like to offer first as Plaintiff's Exhibit 1 a certified copy of the involved application of Reading Barlow Smith together with the final rejection by the Examiner and the decision of the Board of Appeals affirming the Examiner.

The Assistant Clerk: Mark that.

The Court: That may be admitted. No objection?

Mr. Cochran: No objection.

(Certified copy of Smith application, rejection, and decision of Board of Appeals, was marked Plaintiff's Exhibit 1 and received in evidence.)

By Mr. Forward:

24 Q. Mr. Smith, will you give your full name and your occupation and your present employer? A.

Reading Barlow Smith; occupation, engineer in development department, Sinclair Refining Company.

Q. Mr. Smith, what has been your technical education?

A. Bachelor of Science degree in chemical engineering from Bucknell University; graduate work at Massachusetts Institute of Technology.

Q. Would you give just a general description of the nature of your work and also tell us how long you have been employed in that capacity?

The Court: Will you not talk a little more loudly, please?

The Witness: Yes. I have been employed by Sinclair for about 13 years. The nature of the work is development of oil refining processes involving cracking and other distillation units.

By Mr. Forward:

Q. Has your work involved your becoming familiar with the cracking processes as practiced by the Sinclair Refining Company and by its competitors to any extent? A. It has. I am familiar with the Sinclair cracking processes, and as much as I could be from what I read in the literature of my competitors' processes.

Q. Mr. Smith, you are the applicant named in the application involved in this case? A. I am.

Q. Would you give a rather brief general division of the types of oil cracking processes that have been used extensively in the industry? A. These can be divided into three groups that have been extensively used. The first
25 group is the bulk pressure distillation characterized by the Burton still; the second group is the tube and tank process characterized by Dubbs, Cross, Holmes, Manley; and the third is the high-pressure coil cracker, of which Winkler-Koch is the outstanding example. There are other processes, such as catalytic cracking, low-pressure vapor phase, which have been used to a much lesser degree than the three general types.

Q. Now, confining your answer to those three main, broad classifications, would you give a very short and brief description of the outstanding and distinguishing characteristics of each type, each of those three types of process? A. The bulk pressure distillation: the oil is distilled in bulk under pressure at a very slow rate. In the neighborhood of 2% per hour of the oil is distilled.

In the tube and tank type processes the oil is heated more rapidly than in the bulk pressure distillation units.

By the Court:

Q. You refer to bulk pressure units. You mean that the oil is placed in a big tank or vat, and heat is directly applied? A. That is right.

Q. And the second type of process which you mention is a combination of the bulk and the tube and tank processes?

A. No, sir, it is hardly a combination of both. The oil goes through a tube where the tube is heated, and then from the tube it goes to a tank that is maintained under pressure.

Q. After the process is over, that is, after the heating process is over? A. After the heating process is over, and then from the tank—after the tank the pressure is
26 reduced, but the tank is where the main cracking or most of the cracking takes place.

By Mr. Forward:

Q. Is the tank conventionally heated or unheated? A. Unheated tank.

Q. But the cracking goes on there by virtue of residual heat picked up in the coil in the tube and tank process?

A. Yes. And in the high-pressure coil cracker the oil is heated still more rapidly than in the tube and tank processes. The coil can be divided into more or less two parts. In the first part the oil is heated to temperature, and then it is maintained at that temperature in the remaining part of the coil, known generally as the soaking section, and most of the cracking takes place in this soaking section of the coil. The heating part of the coil is heated more rapidly than the soaking section. After the oil leaves the coil—soaking section—the pressure is reduced, and it goes to a tank where the further separation takes place. No further cracking takes place after reduction of pressure.

Q. In the conventional high-pressure coil type system you mentioned that the first section was heated more rapidly than the later or soaking section of the coil. How is that conventionally accomplished? A. In most cases the more rapid heating is accomplished in the radiant section of the furnace. The tubes are located in the radiant section of the furnace, while the soaking coil is generally located in the convection section of the furnace where the tubes are shielded from radiant heat. In some cases there may be two heaters, and one heater is fired more rapidly than the other.

27 Q. In the tube and tank type process is the coil conventionally shielded or unshielded? A. It is conventionally shielded in the tube and tank.

Q. I should like to have you refer briefly to this book. I hand you a copy of the Handbook of Petroleum, Asphalt and Natural Gas, by Cross, which is I believe a recognized authority in oil cracking, is it not? A. It is.

Mr. Forward: I think Mr. Cochran will agree to that, because it has been used by the Patent Office a great deal.

By Mr. Forward:

Q. I should like to have you refer to pages 332 and 333, and ask you if that is a conventional illustration of the Dubbs embodiment of the tube and tank process as it is conventionally used. A. It is.

Q. Would you point out just where the tube and tank are and the location of the coil in the furnace with respect to the firebox; that is, the fire, as you say; that is, whether it is shielded or not, and how the shielding is accomplished?

A. Yes. This is the fire on this side where the furnace is heated (indicating). This is the bridge wall where the tubes are located away from the fire. The flue gases come over the bridge wall and pass down over the tubes. The oil comes in through this pipe, passes through these coils, then to this tank (indicating).

Q. Would you mark on this photostat copy of that drawing the coil and the chamber? Mark the coil in blue, "A".

A. Just show an arrow to it?

28 Q. That is right. And the chamber "B", because the record does not very well indicate what you mean by "this coil" and "this tank." A. "Coil A" and "Tank B" (marking drawing).

Q. Now will you refer to pages 322, 324, and 325 of that handbook, and I will ask you if that is a conventional illustration of the standard Cross process, and in particular, if you feel that it is, I should like to have you describe the cracking part of the system; that is, the tube and the tank in that process. A. This is a Cross process. The oil comes in through line 23 it's marked on the drawing, through the upper tube bank.

By the Court:

Q. Line 23. I see it. A. Then it crosses over from the upper tube bank down to the lower tube bank marked 4. The upper one is marked 3.

Q. You say the first is 23? A. Yes. 23 is the line coming here (indicating).

Q. Now, where does that go? 23 comes down to where? A. Through the tube bank; it's marked 3. The coil, the circle is.

The Court: I see.

Mr. Forward: This is the chamber (indicating).

The Witness: And then from the coils 4 it goes into this tank marked 9, and the oil is heated in the coils and passes from the coils to the tank where the majority of the cracking takes place.

By the Court:

29 Q. The coils being 3 and 4? A. Yes, sir.

Q. And 5 being the heating arrangement? A. Yes, sir.

The Court: I see.

By Mr. Forward:

Q. Will you indicate whether or not that coil is shielded, and if so how it is accomplished? A. The furnace is fired at a point marked 5. Above this marking you can see a shield between the fire and the tubes.

By the Court:

Q. You are referring to that vaultlike structure there? A. Yes, sir.

By Mr. Forward:

Q. You call it perhaps an arch? A. An arch.

Q. Fire brick arch? A. Yes.

Q. I should like to have you refer to Behimer patent 1,883,850 and tell me whether or not that is a conventional illustration of the—

The Court (interposing): Now, is this being offered?

Mr. Forward: Eventually I want to offer all three of those as one, as illustrative of the tube and tank.

The Witness: This is.

Mr. Forward: Did I finish the question?

(The pending question, as above recorded, was read by the shorthand reporter.)

By Mr. Forward:

30 Q. (Continuing) —of the Holmes Manley tube and tank process? A. It is.

Q. Would you make a similar explanation with respect to that process, referring particularly to the drawing, the way you have just done with respect to the Cross and the Dubbs processes? A. The charge stock is pumped through the coils from line 7 on the drawing.

By the Court:

Q. Yes. A. It passes through coil 1 where it is heated. The firing takes place from 3, and the arch 5 shields the tubes from the fire. The oil passes—

Q. (Interposing) Those vents 6 are where the gases get up around the tubes? A. Yes. The oil leaves the heater through line 9 to the soaking drum or tank marked 11-a. It is this drum 11-a where the majority of the cracking takes place. This drum is maintained under the pressure of the coil.

By Mr. Forward:

Q. Is that coil also shielded in that system? A. It is.

Q. What is the shield? What serves as the shield in that case? A. Marked here 5.

Q. Baffle 5? A. Baffle 5.

Mr. Forward: This is the shield (indicating).

31 The Court: Yes, I know that, and I asked him also whether or not 6 indicates vents by which the gases formed in the fire reach the oil, reach the tubes.

Mr. Forward: That is, that is to protect them from a large amount of radiant heat, permitting some of the gases to go through and heat by convection.

I should like to offer in evidence, as Plaintiff's Exhibit 2, a photostatic copy of pages 332 and 333 of the Cross Handbook to which the witness has just referred and which show the typical Dubbs process; and as Plaintiff's Exhibit 3, a photostatic copy of pages 322, 324, and 325 of the same Cross Handbook, to which the witness has just referred and which show the typical Cross tube and tank installation; and I should like to offer as Plaintiff's Exhibit 4 the Behimer patent 1,883,850, which illustrates the conventional Holmes Manley type of process.

The Court: This is all addressed to the state of the prior art?

Mr. Forward: That is correct. What I am attempting to do here is build up to the fact that when you talk about "rapid" you may mean almost anything, because here is this O. Behimer application that even talks about its being rapid. So that a mere statement in the prior art that something is done rapidly is no disclosure of this unusual and

critical and surprising thing that no one ever thought of before, because it falls in that class of cases like the Mineral Separation case where the degree goes to a point where you have, all of a sudden, a brand new function that appears.

By Mr. Forward:

Q. I show you a drawing which does not purport to be much more than a flow diagram, and ask you what type of cracking process that represents, if you know.

32 A. That is the high-pressure coil type of process that is typified by Winkler-Koch.

Q. The Sinclair Refining Company has installed and has operated a still of this character, with which you have had direct contact? A. The Sinclair Refining Company has had such a still and operated it, and I have had contact with it.

Mr. Forward: I think it will help a lot; I have some smaller ones of these which I can hand to the Court (referring to drawings).

(A drawing was placed on a blackboard.)

Mr. Fisher: Can your Honor see that from where you sit?

The Court: When he comes to point and use it I will get down from the stand.

Mr. Forward: Your Honor, this is a smaller one, of that (handing a drawing to the Court).

By Mr. Forward:

Q. Mr. Smith, would you give a brief description of the operation of the cracking portion of that process, of the process illustrated in that flow diagram? We shall not be interested in the fractionating equipment. A. The oil is pumped to the heater through line 7-c.

By the Court:

Q. I have not found that. A. That is down at the bottom.

Q. I see. A. In through this preheater section labeled "bank 1." It leaves the preheater section and goes through—

33 Q. The second bank? A. The second bank. Then through the third bank or roof tubes; then from the roof tubes it goes through the fourth bank and fifth bank, which are the soaking section. This is the section of the furnace—that is the fourth and fifth banks—where the cracking takes place, most of the cracking, while the other parts of the furnace are bringing the oil up to temperature for it.

It leaves the fifth bank, and the pressure is released at valve 10, flows from there to this separator drum marked 11-a; I guess that would be a good nomenclature for that. There are several others here. There is substantially no cracking that takes place in the drum. The temperature is reduced, and the pressure is reduced in the drum.

By Mr. Forward:

Q. Which are the sections in which the heating is rapid in this arrangement? A. The heating is rapid in the second and third banks. The temperature is raised from 665 degrees to 911 degrees in those banks.

Q. Which are the sections in which the—

By the Court:

Q. (Interposing) Nine hundred and twenty-two degrees when it gets into the cracking bank 4, isn't it? A. Well, that is leaving the first cracking bank. You see, it is entering the first cracking bank from that 911 point.

Q. Well, in other words, what I was curious about was this: that the highest temperature apparent is 911 degrees;

that is when the oil reached the third bank. Then it goes down into what you might call the cracking bank, and the temperature rises there 21 degrees without so much heat being applied as there was in the so-called heating banks. A. That is right, yes, sir.

Q. What is the explanation of that? A. In these cracking banks, it is only necessary to supply the heat of cracking. It is not necessary to supply any heat to increase the temperature of oil.

Q. But the temperature in the cracking bank is 21 degrees higher than in the so-called heating bank 3 where you are applying presumably direct heat. Or 11 degrees higher, I mean to say. A. Eleven, yes.

The Court: It probably hasn't got a thing to do with it; undoubtedly hasn't.

Mr. Forward: Would it be helpful in clearing this up if I ask the witness:

By Mr. Forward:

Q. Is the amount of heat required to raise the temperature all the way from 665 up to 911 more than the amount of heat required to raise it only from 911 to 926, at which temperature it emerges? A. It most certainly is.

Q. In one instance you have a large amount of heat required for a large temperature rise, and in the other instance you have some further heating, but the temperature rise is relatively small, and a relatively small amount of heat or heating is required to do that. What is the pressure maintained at the coil outlet in conventional Winkler-Koch type operation? A. You say what is the—

35 Q. The pressure maintained at the coil outlet. A. In the neighborhood of 400 pounds.

Q. What will be the pressure at the coil inlet? Will that vary, I presume? A. That will vary with the amount of stock fed through the coil; and, for example, if the through-

put is small it may be 800 pounds. If it is large it will be in the neighborhood of 11 or 12 hundred pounds.

Q. What makes the pressure higher at the coil inlet? Is there anything other than frictional resistance to make the pressure higher at the coil inlet? A. No; just the pressure drop through the coil.

Q. Due to frictional resistance? A. Due to the frictional resistance.

Q. In the operation illustrated in the chart the coil inlet pressure is given as 1,150 pounds. Is that typical of Winkler-Koch operations? A. It is.

Q. Now I hand you a certified copy of Plaintiff's Exhibit 135 in the case of the Texas Company v. Anderson-Prichard Refining Corporation, which shows or purports to show the Winkler-Koch process which was the process charged to be an infringement in that case. Does that conform to the drawing that you have just described? A. It does, sir.

Q. Is it identical except for the legend at the top? A. It is.

The Court: Now, this is an infringement decision; is that it?

36 Mr. Forward: It is, but all I am concerned with is the description of the defendant's process, which is a Winkler-Koch process.

The Court: Well, may I ask you, how well does that conform with this proceeding here?

Mr. Forward: The Court's decision in that case contains a rather concise description of the defendant's Winkler-Koch operation, which is perhaps appealing to someone other than a technologist, and this witness has already practically described the Winkler-Koch operation from his own contact with the Winkler-Koch still, and there is always the inference in these 4915 actions that the defendant does not have the opportunity of direct contact with the industry. I merely wanted to supplement—

The Court (interposing): Well, may I ask this, to clear it up in my own mind by asking you this question: Is this the process in issue in this case, this process that we are now discussing?

Mr. Forward: The process in issue in this case—if you mean the trial at bar—is a very slight modification of this Winkler-Koch process, ever so slight, and when once we get to this point we will show you how slight the transition is.

The Court: I mean, is the patent issued?

Mr. Forward: No; that Winkler-Koch process has just been a process that has developed. Everybody sued, brought suit against it because it was a good process. There was no patent issued for this Winkler-Koch process. It was just a process that went into extensive commercial use by a great many people.

The Court: Then, this process has been questioned by a number of people who have patents?

Mr. Forward: That is right.

37

The Court: Their view being that this process was an infringement on their patents?

Mr. Forward: That is what I wanted to say, yes.

The Court: Is there any objection to this, Mr. Cochran?

Mr. Cochran: I wondered all along how pertinent these matters were to the issue here before the Court, but at the same time I won't object to it.

The Court: Well, I understand what counsel plans, as far as the technology of the case is concerned, is to show the state of the prior art and now presumably to show that this is a process, an unpatented one, the one we are discussing now,—

Mr. Forward (interposing): That is correct.

The Court: —that has been questioned, in the sense that it has been viewed in some instances, out of which litigation arose, as an infringement on processes that there were patents issued for.

Mr. Cochran: I won't object to it.

Mr. Forward: All right.

By Mr. Forward:

Q. I refer you, Mr. Smith, to the decision of the Circuit Court of Appeals for the 10th Circuit in the case of the Texas Company v. Anderson-Prichard Refining Corporation, and on pages 829 to 842 of the Federal Reporter, 122 Fed. 2d, and particularly to the description of the defendant's process, starting with the second column on page 834, and continuing through to four lines from the bottom on the first column on page 836; and I should like to ask you whether that is a description of the Winkler-Koch operation as you know it. A. It is.

38 Q. I should like to have you refer to the sketch appearing on page 835 of this decision, and I should like to ask you whether or not that has any relationship to the drawing about which you have been testifying, as illustrative of the Winkler-Koch process. A. I would say it is the same drawing essentially, as far as the flow diagram is concerned, as the one I have been discussing. They haven't shown the heater sketched in, but if you observe the heating tubes and visualize the heater around those tubes then it would be the same drawing.

Q. Would you call it simply a somewhat simplified and streamlined drawing, or illustration, of the same process? A. I would.

Mr. Forward: I should like to offer in evidence as Plaintiff's Exhibit 5 a certified copy of this drawing of the Winkler-Koch process, which was offered as Plaintiff's Exhibit 135 in the Anderson-Prichard case to which we have referred, and Mr. Cochran has kindly stipulated that I may substitute a photostatic copy for the certified copy, and that is the drawing at which you have just—

The Court: Just looked.

Mr. Forward: Yes. Will you mark this as Plaintiff's Exhibit 5?

(Flow diagram, offered in Anderson-Prichard case, was marked Plaintiff's Exhibit No. 5 and received in evidence.)

39 The Court: Suppose we recess for five minutes to give you a chance to straighten out your exhibit numbers.

Mr. Forward: All right.

(Photostatic copy of pages 332 and 333 of Cross Handbook was marked Plaintiff's Exhibit No. 2 and received in evidence.)

(Photostatic copy of pages 322, 324, and 325 of Cross Handbook were marked Plaintiff's Exhibit No. 3 and received in evidence.)

(O. Behimer patent 1,883,850 was marked Plaintiff's Exhibit No. 4 and received in evidence.)

(There was a brief, informal recess, at the conclusion of which the proceedings were resumed as follows:)

(The witness resumed the stand.)

By Mr. Forward:

Q. Now, in this portion of the decision in the case of the Texas Company v. Anderson-Prichard Refining Corporation which describes the defendant's operation it also describes the rate of flow of the oil in the different sections of the coil to some extent. Have you examined that to a sufficient extent to find out whether or not that gives you enough information to calculate approximately the time required for the oil to pass through sections 2 and 3, tube banks 2 and 3 of the furnace? A. I have examined this, and there is sufficient information to make such a calculation.

Q. Have you made such a calculation? A. I have.

Q. And approximately what is the time required for the oil to pass through there? A. Two point seven minutes.

40 By the Court:

Q. You mean two and seven-tenths minutes? A. Yes, two and seven-tenths minutes.

Mr. Forward: I call your attention to a copy of Defendant's Exhibit 537 in the Anderson-Prichard case, and Mr. Cochran will stipulate, I believe, that we may use this photostat in lieu of the certified copy, for the purpose of this record.

Mr. Cochran: Yes.

By Mr. Forward:

Q. Does that indicate the time required for the oil to pass through sections 2 and 3 of the furnace? A. It does.

Q. And how does that value compare with the one which you independently calculated? A. Very closely.

Q. How is it indicated on this drawing? A. It is indicated to be 38 seconds in the second bank and 68 seconds in the third bank.

By the Court:

Q. Now, what does that mean? It means that the oil is 38 seconds in the bank or takes 38 seconds to go through the bank, which I presume is the same thing. What do you mean by that? You have a graph here. A. Yes, sir.

Q. With "120 seconds first bank, 38 seconds second bank, 68 seconds third bank." Well, now, will you explain that to me with reference to the time element? I haven't got it quite clearly in my mind as to what you mean. In other words, to be perfectly frank, I do not understand
41 this graph. It refers to coil volume in cubic feet, and then we go into a discussion of the time element, 68 seconds. I do not understand the relationship.

By Mr. Forward:

Q. Will you try to explain the relationship of that graph?

By the Court:

Q. Will you explain the graph to me with reference to this process? A. Yes, sir. This (indicating), the bottom curve, plots temperature versus the time that an increment of oil starts at the beginning of the heater and passes throughout the full length of the heater. In other words, the summation of this time is a time that the oil would require to pass through the full length of the heater.

I am sorry. I didn't state that just correctly. The plot is temperature versus the number of tubes, the tube number here.

In other words, the temperature at tube 50 is 625 degrees approximately, and the temperature at tube No. 100 would be 750 degrees; and leaving the heater or tube 220, 925 degrees.

By Mr. Forward:

Q. Aren't you referring to the time instead of to the temperature—to the tube chart—when you give those values? A. Well, the plot is the tube number. The time has been calculated between those, but the plot is on the tube number.

Q. Are there not two curves illustrated on that drawing? A. There are.

Q. Does not one of those relate to tube length and the other to time—I should say, to tube number and the other to time, both being plotted against temperature?

42 A. That is correct.

Q. Which one is the one that refers to tube length or tube number? A. The top curve is temperature versus tube length.

Q. And the second curve is just a matter of time in seconds, is it not? A. It is.

Q. And that is marked in seconds per bank? The abscissa is actually marked in seconds per bank rather than in tube numbers for that, is it not? Is not this line (indicating), this horizontal line just below the time curve, the abscissa for the time curve? A. It is.

Q. And from that abscissa how long would be the time required to go through the second bank and the entire third bank? A. This curve shows 38 seconds through the second bank and 68 plus 49 seconds through the third bank.

Q. And the total value of that number of seconds is how many minutes, approximately? A. Two and seven-tenths minutes.

43 By Mr. Forward:

Q. Why is there a difference between the curve based on time and the curve based on the coil volume? Why are they not the same? A. The oil expands as it goes through the heater, and therefore the time is longer when the oil is cold than it is when it is hot.

Q. The time you have given as 2.7 minutes, then, is the time required for the oil to travel through tube bank No. 2 and tube bank No. 3; is that correct? A. It is.

Q. In this type of operation that we have been discussing, illustrated by this chart of the Winkler-Koch process, when you have a coil outlet pressure of 400 pounds and a coil inlet pressure of 1,150 pounds, approximately what would be the pressure at the time it came out of tube bank No. 3? A. Approximately 900 pounds.

Q. I refer you to a copy of Plaintiff's Exhibit 136 in the case of Texas Co. v. Anderson-Prichard and ask you if that gives you any indication of the pressure change through the coil or the pressure at various points in the coil. A. It does.

Q. Where is that illustrated? A. That is illustrated in the curve marked "Pressure."

Q. What would be the pressure, approximately, at the outlet of bank 3? A. Eight hundred and eighty pounds.

44 Mr. Forward: I would like to offer in evidence as Plaintiff's Exhibit No. 6, as a matter of convenience, a photostatic copy of the Federal Reporter report in the suit of the Texas Company against the Anderson-Prichard Company in the Circuit Court of Appeals for the Tenth Circuit. The citation is 122 Fed. (2nd) 829.

(Photostatic copy of Federal Reporter relating to Texas Co. against Anderson-Prichard Co. was marked Plaintiff's Exhibit No. 6 and received in evidence.)

As Plaintiff's Exhibit 7 I offer in evidence a photostatic copy of the Federal Supplement, pages 347 to 354, Volume 32, which is the report on the same case in the District Court. I mention that and would like to offer both, because the Court of Appeals' report has not identified this as the Winkler-Koch operation at all, whereas the District Court decision goes into great detail about it. They both agree in the final outcome. It was an affirmance.

(Photostatic copy of Federal Supplement, pages 347 to 354, was marked Plaintiff's Exhibit No. 7 and received in evidence.)

I should like to offer as Plaintiff's Exhibit 8 a certified copy of Defendant's Exhibit 537 in the Anderson-Prichard case; and it has been stipulated that a photostatic copy may be substituted for the certified copy.

(Photostatic copy of Defendant's Exhibit 537 in Anderson-Prichard case was marked Plaintiff's Exhibit No. 8 and received in evidence.)

As Plaintiff's Exhibit 9 I offer a similar photostatic copy of Plaintiff's Exhibit 136 in that case.

(Photostatic copy of Plaintiff's Exhibit 136 in Anderson-Prichard case was marked Plaintiff's Exhibit No. 9 and received in evidence.)

I should like to call to the Court's attention that was it Behimer patent, which has been offered as Plaintiff's Exhibit 4, which is the patent involved in the Anderson-Prichard case which it was charged was infringed by the Winkler-Koch process.

I should also like to offer as Plaintiff's Exhibit 10 a copy of the Howard and Loomis patent, No. 1,869,337, and as Plaintiff's Exhibit 11 a copy of Dubbs patent 1,392,629. I should like to call the Court's attention to the fact that the Howard and Loomis patent to which I have just referred is the property of the Gasoline Products Company and was the subject of a patent suit in which this Winkler-Koch type of process using rapid and mild heating was charged to be an infringement. That case is reported in 86 Fed. (2d) 552. The suit was against the owner and operator of the Winkler-Koch still.

(Copy of Howard and Loomis patent 1,869,337 was marked Plaintiff's Exhibit No. 10 and received in evidence.)

(Copy of Dubbs patent 1,392,629 was marked Plaintiff's Exhibit No. 11 and received in evidence.)

I also offer in evidence as Plaintiff's Exhibit 12 a copy of Donnelly patent No. 1,712,789.

(Copy of Donnelly patent No. 1,712,789 was marked Plaintiff's Exhibit No. 12 and received in evidence.)

I should like also to call attention to the fact that Dubbs patent 1,392,629, which has been offered as Plaintiff's Exhibit No. 11, was the subject matter of a suit by the Universal Oil Products Company against the Globe Refining Company, another operator of the Winkler-Koch type of still. That case

46 is reported in 40 Federal Supplement, 575. The District Court dismissed the complaint, and in that case the appeal is still pending.

The purpose of this is to bring to the court's attention the fact that this coil cracking process with relatively rapid heating in the first part and relatively mild heating in the second part, was the subject of very extensive patent litigation, because it began to be too much of a competitor, and they just swarmed all over operator of that type of still with patent suits.

The Donnelly patent which I offered in evidence as Plaintiff's Exhibit 12 was also the subject of litigation in the Western District of Louisiana. That case, Donnelly Process Corp. v. Oil Refineries Inc., Equity No. 601, pended for some five years. The suit was filed in 1934, and the case was finally dismissed, after a lot of harassing tactics. But in all of those four suits the question of infringement invariably turned on the condition of the oil inside of the heating coil.

By Mr. Forward:

Q. Mr. Smith, in 1936 did you have occasion to make an extended investigation of the condition of the oil in these high-pressure coil types of cracking processes? A. I did. My employer was interested in knowing just what was going on. He wanted the facts of the matter, and I participated in that investigation and investigated the condition of the oil in various cracking processes.

Q. Were you given any understanding as to why your employer was so much interested in investigating the condition of the oil within the coil of that type of still? A. I understood there was considerable litigation, and he wanted to know just where he stood in the matter.

47 Q. I hand you a drawing which I shall ask the reporter to mark "Plaintiff's Exhibit 13," and ask you to tell me what that shows.

(A drawing handed to the reporter was marked Plaintiff's Exhibit No. 13 for identification.)

A. This is a diagram of the apparatus we built for determining the condition of the oil in a cracking coil.

Q. Will you give just a general description of that apparatus from the drawing? A. The object of this apparatus was to subject the feed stock in the cracking coil to various times, pressures, and temperatures, and observe the phase condition and volume.

Q. How did you observe it? A. The apparatus was so constructed that the sample was contained in a glass tube and was heated by means of a heater with a window so that we could see the phase condition as well as measure what we saw.

Q. Did you see it throughout the heating? I would like a little more detailed description of where the sample was confined. A. The sample was confined in the upper part of this tube that is marked at the top "Pyrex Reaction Tube." It was held there by means of a sealing medium of liquid metal, used similarly to the way in which mercury is used in laboratory experiments. Pressure was imposed on the sample by means of this ram pump indicated with the crank, and the pressure was measured.

Q. Will you mark that ram pump with the letter "A"?

(The witness marked the drawing as requested.)

48 Q. Where did you read the pressure that was applied? A. On the pressure gauge.

Q. Mark that "B". A. It is marked "B".

Q. How was the sample heated? A. The sample was heated by means of an electric furnace marked "C". This furnace is constructed with wire heating coils.

The Court: Four amperes each?

The Witness: That is correct, sir. Heat from the electrical furnace was transmitted to the sample tube. This furnace, as before stated, had a glass window in front so that we could always observe the full length of the sample.

By Mr. Forward:

Q. How did you control the heat? A. By means of a rheostat which governed the amount of electricity through the coils.

Q. What was the relationship of the heating capacity of the furnace to that sample? A. It was extremely large, and we could obtain almost any rate of heating we desired, much more than any other apparatus that I know of.

Q. Would you please describe the carrying out of one test in that apparatus after you had the sample in place in the tube? A. After the sample has been placed in the tube, pressure is maintained by means of the ram pump. The electrical current is turned on and the temperature is read by means of a thermocouple that goes up
49 through the open end of the tube and is directly in the sample. If we desired a test where the heating was rapid we would turn the rheostat so we had the maximum amount of heating, and then we would read the temperature of the sample and the pressure and the time from the beginning of the run and, by means of a cathetometer, would measure the level of the oil in the sample, and if there was a phase separation or two phases we would measure the level between the liquid and the vapor phase at any time throughout the run.

Q. You heated a sample of gas-oil typical of the charge stock used commercially in Winkler-Koch type stills? A. Yes.

Q. And when you heated it at a rate such as encountered in the ordinary commercial operation of those stills, what did you find to occur? A. At a certain point in these runs

a small bubble of vapor would first show above the sample, and the vapor would gradually increase until approximately 90 percent of the total sample volume would be vapor; but there would still be 5 to 10 percent liquid that would remain throughout the run and would never disappear, regardless of the conditions.

Q. And would that condition prevail even though the pressure applied to the sample exceeded the critical pressure on that sample? A. It would.

Q. Did you make any other discoveries in the course of making these tests? A. I did.

Q. Will you please tell us what they were? A. I was
50 curious to see what effect there would be upon the
sample if I started by subjecting it to the critical
temperature almost instantaneously. Of course
we cannot do that completely, but I cut it down to the very
minimum; and, when I reduced the heating up time down
to a minute or two minutes, when I reached the critical
temperature, instead of a small bubble of vapor showing,
the sample instantaneously changed from the liquid to the
vapor phase and remained in the vapor phase. The liquid
never appeared again during the run.

Q. It never reappeared even though you maintained the temperature for a period of time long enough to do a large amount of cracking? A. That is correct.

Q. More than in any commercial cracking process? A. That is correct.

Q. Did you run a series of these tests on any one oil sample? A. Yes; I did; approximately 200 on one sample that I know of.

Q. I hand you four sheets which have a legend in the upper right-hand corner, "Run 1," "Run 2," "Run 3," and "Run 4." I will ask you if you know what those are and, if you do, will you please tell us? A. These are the plots of the results of test runs. Each run was plotted against time and temperature. Run 1 shows that when the time, from 650 degrees to 940 degrees, was about a minute and

a quarter, complete vaporization occurred at 945 degrees. The dotted line indicates the total volume; and no liquid volume is shown there; and you will observe that no liquid ever appeared again in that run, although the run was continued for ten minutes.

51 Q. What is the relationship of the ten minutes taken at that temperature to anything that you would encounter in the Winkler-Koch type of operation?

A. That is extremely long. In the Winkler-Koch type of operation, from the time the oil enters and leaves the heater is generally about six minutes.

Q. Clear through the entire high-pressure coil? A. That is right. Run No. 2 is similar to Run No. 1. It shows the same phenomena were observed when the heating time, between 650 and 940 degrees, was two minutes.

Run 3 shows the time between 650 degrees and 940 degrees as about four and one-half minutes, and it shows that instead of the sample vaporizing completely it split into two phases, with the liquid phase always remaining throughout the ten-minute run.

Run 4 is similar to Run 3. The time, to 940 degrees, was about 6 minutes, and this also vaporized and showed separation between liquid and vapor with the liquid always remaining and never disappearing throughout the run.

Q. Did this sudden and complete vaporization that you found to occur in this run with a very high initial heating rate, together with the fact that no liquid tar ever formed after the vaporization, even though you had a continued cracking, involve any departure from the generally accepted theory of cracking as of that time? A. It certainly did. We were making these studies, and the accepted theory was that the more you cracked the more you would be inclined to be in the vapor phase. But here we had liquid

tar. When we went to the short time and had it
52 completely in the vapor phase we had to change our theories, because prior to that time we always had tar. In this experiment we had no liquid phase.

Q. And no tar was discernible at any time? A. No tar was discernible at any time.

The Court: In this phase of the experiment which you first mentioned, referring, now, to the pyrex tubes and the heat applied by electrical heating elements, you said you had liquid remaining and about 90 percent vaporization?

The Witness: That is what we generally found.

The Court: That was your first experiment before you went to the process of applying still greater heat and applying it as instantaneously as you possibly could, until you got entire vaporization, as I understood your testimony?

The Witness: Yes, sir.

The Court: Having in mind this first experiment which you testified to, where you had 5 to 10 percent of liquid remaining, that is oil remaining in this pyrex tube on the first application of the electrical heat, was there anything in the nature of a coal tar product remaining in the liquid?

The Witness: Yes, sir.

The Court: So that your theory was that the quicker the vaporization by the application of higher instantaneous heat, the more this difficulty was obviated; is that it?

The Witness: Yes, sir. You see, in all cracking processes this tar always showed up, and we accepted it as being there. We tried to reduce it, but no one had ever eliminated it before.

53 The Court: I just wanted to make sure what your testimony was in that respect.

Mr. Forward: I would like to offer in evidence as Plaintiff's Exhibit 13 a drawing of the test apparatus which has been identified.

(Drawing of apparatus heretofore marked for identification as Plaintiff's Exhibit 13 was received in evidence.)

I would like to offer as Plaintiff's Exhibit 14 the curves for Run No. 1 on the test apparatus.

(Curves for Run No. 1 marked Plaintiff's Exhibit No. 14 and received in evidence.)

I should like to offer in evidence as Plaintiff's Exhibit No. 15 the curves for Run No. 2; as Plaintiff's Exhibit No. 16 the curves for Run No. 3, and as Plaintiff's Exhibit No. 17 the curves for Run No. 4.

(Charts showing curves for Runs Nos. 2, 3 and 4 were respectively marked Plaintiff's Exhibits 15, 16 and 17 and received in evidence.)

By Mr. Forward:

Q. These tests were made by you, were they? A. They were.

Q. And you have examined these curves and they accurately reproduce the results as you found them? A. They do.

Q. Did you notice as you varied the rate of heating whether there was any change in the temperature at which the point of vaporization first became apparent? A. I did. When the heating time was low this temperature was about 945 degrees. When the heating time was longer
54 the initial vaporization started about at 915 degrees.

Q. I hand you a sheet entitled "Initial Vaporization Point from PVT Data" and will ask you to explain what that shows. A. This table shows the initial vaporization temperature with respect to the heating time. PVT means the relationship of Pressure, Volume, and Temperature.

Q. Would it be a correct statement to say that these temperatures in this column on the right-hand side are the temperatures at which point vaporization first occurred in these tests shown on Exhibits 14 to 17? A. That is right.

The Court: The temperatures in the Pyrex tube in the experiments to which the witness has testified?

Mr. Forward: That is right.

By Mr. Forward:

Q. Do you have any record of the nature and character of the oil on which these tests were made? A. I have.

Q. I hand you a table and ask you if you know what it is and if that will give us any information concerning the character of the oil used in these tests, if it has any relationship at all. A. Yes. The characterizations are shown by the title. Sample No. 9324-50 is the sample of oil that was used in these experiments, and the characteristics are given, the gravity in degrees API 26.3°, and 10 percent, 50 percent, and 80 percent distillation points are also recorded here.

55 The Court: You are using terminology that I am hardly familiar with. I am not familiar with oils to that extent. Take the category after the title B/Stream, degrees API, distillations—what does that mean?

The Witness: That is the distillate overhead.

The Court: What does that mean?

The Witness: When we have a still we distil the gasoline over from a body of liquid.

The Court: A body of oil?

The Witness: Yes, sir. In other words, an example of that would be a tea-kettle, where the steam comes out of the mouth of the tea-kettle.

The Court: What are these other symbols (indicating)?

The Witness: No. 2 tower side stream?

The Court: Yes. That refers to the flow diagram?

The Witness: Yes, sir. (Witness points to flow diagram.)

By Mr. Forward:

Q. Would it be correct to say that so far as the test work on your experimental cracking apparatus is concerned, the only data in that table that are material would be the figures at the bottom for heater feed? A. That is correct.

The Court: I was merely curious as to what these terms meant. I did not want to have this memorandum, so to speak, of experiments placed in evidence and then have the court curious as to what the terminology meant, even though the witness was only referring to the sample marked X.

By Mr. Forward:

56 Q. This sample 9324-50 was taken from material that actually went to the heater? A. Yes, sir.

The Court: Do I understand that that was the sample that was used in this pyrex tube?

The Witness: Yes, sir.

The Court: I hope you will both pardon me for asking these questions.

Mr. Cochran: It is not any clearer to me than it is to you, your Honor, I know.

By Mr. Forward:

Q. This table refers to still No. 611, and all of these charts refer to characterizations of cracking still heater feed under cracking conditions, 611, still heater feed sample 9324-50. What is Still 611? A. Still 611 is the number of the Sinclair Refining Company's cracking still from which the sample was taken. This still, known as one of our 600 series type, is very similar to a Winkler-Koch still.

The Court: I am afraid I am still confused. I understood you were testifying with reference to a series of experiments as a result of which you came upon this new process which you claim is invention, and that that was arrived at by experiments with reference to this pyrex tube and the application of electrical heat to it. Now you are talking about Still No. 611 which has not appeared in the picture up to now.

Mr. Forward: Perhaps I can clarify that by one or two more questions.

By Mr. Forward:

57 Q. Mr. Smith, when you undertook to carry out the tests on this particular apparatus that you designed, in what type of still was it that you were particularly interested in investigating the oil condition within the coil? A. Our 600 series type still, which is very similar to a Winkler-Koch still.

The Court: Then he is now proceeding from the theoretical, experimental stage, so to speak, and proceeding with his experiment on a still used by the Sinclair people. In other words, he is coming out of the Pyrex tube stage of the experiment and now using a still?

Mr. Forward: No, sir. I am afraid I am misleading you. The still operation he is talking about is on still 611, an operation which was being carried out commercially by the Sinclair Refining Company. They were interested in investigating the condition within the coil of that type of still because of all this litigation turning on that point, and naturally the kind of oil that they wanted to investigate was not some oil in a tank. They did not take a sample from a tank out in the field. They went

right to one of their 600 type commercial stills, and they just happened to select still 611 as an example, and they took their sample right from the heater feed, because that was the material that was going into the coil, so that if they ran tests in their Pyrex tube apparatus on that particular oil they would be reproducing the conditions within that coil if they so ran their test.

The Court: Now I understand the situation to be that when they came to the point of making the experiments, came to the necessity of selecting the oil they were to experiment with on this apparatus devised by Mr. Smith they went to one of the commercial stills and picked out an oil that was being processed and commercially used?

58

Mr. Forward: That is right, sir.

I should like to offer in evidence the sheet entitled "Initial Vaporization Point From PVT Data," as Plaintiff's Exhibit No. 18.

(Sheet entitled "Initial Vaporization Point from PVT Data" was marked Plaintiff's Exhibit No. 18 and received in evidence.)

I should also like to offer as Plaintiff's Exhibit No. 19 the second sheet referring to No. 611 Still operating data.

(Second sheet relating to data on still No. 611 was marked Plaintiff's Exhibit No. 19 and received in evidence.)

By Mr. Forward:

Q. I wish you would look at Howard and Loomis patent 1,869,337, and tell us whether or not the apparatus and process there disclosed are at all similar to your process.

A. The process there is not similar to the process that we are speaking of.

Q. What are the general characteristics of the process of the Howard and Loomis patent? A. The general char-

acteristics are that the oil is heated and cracked in the liquid phase. In order not to form coke they heat it mildly between 725 and 800 degrees, 800 degrees being about top temperature. But the patent suggests heating it rapidly between 500 and 725 degrees.

Q. First of all, I would like to ask you whether this maximum temperature of 800 degrees they talk about is any place near the critical temperature? A. No. It is about 150 degrees lower than the critical
59 temperature.

Q. These degrees you are referring to are Fahrenheit degrees? A. That is correct.

Q. In the process of that patent the oil goes through coil 10 and then through coil 15, referring to Figure 1, and it is in these coils that the oil is heated and cracked, is it not? A. It is; yes, sir.

Q. The patent refers to heating the oil rapidly, does it not? A. It does.

Q. Does it give you any indication of what it means when it uses the word "rapid"? A. Apparently it obviously does not mean what I mean by rapid. Taking the data that they give here the time is 12 minutes to heat the oil.

Q. You can determine that 12 minutes from what data? A. They give the feed stock at 500 gallons per hour, a 2-inch diameter coil 800 feet long.

Q. When you say 12 minutes you are referring to the time required for the oil to pass only through coil 10? A. That is correct.

Q. In other words, it requires 12 minutes to heat from 500 degrees to around 725 or 750 degrees Fahrenheit, and it uses the word "rapid" to describe that kind of heating. How would that rate of heating compare with the Winkler-

Koch type process? A. It would be much slower
60 than the Winkler-Koch type operation.

Q. How would it compare with your process? A. Extremely slow, compared with ours.

Q. I would like to have you refer to Peck patent 1,933,507, which has been cited by the Patent Office as showing a process similar to yours. Does that patent disclose any initial heating at any extremely rapid rate and does it give you any reason for even trying to heat at a very rapid rate, or are its teachings to the contrary? A. The teachings are to the contrary. It states that you can crack 25 percent of the stock when the temperature of 850 degrees is reached and it is still satisfactory. They do state a short time, and they crack up to 25 percent. That is not what we are talking about as a short time.

Q. Do I understand you as saying that you may crack up to 25 percent or more before you reach the point of complete vaporization? A. That is correct.

Q. In accordance with this patent? A. That is correct.

Q. You certainly would not call that heating at a rate so that you reach the critical temperature before you have an opportunity to have some substantial conversion? A. No, sir.

Q. When you use the words "substantial conversion" in describing your process, do you use "substantial" in a strict sense meaning merely an unavoidable trace? A. That is correct.

Q. Is it possible, no matter how rapidly you
61 heat, to completely avoid decomposition? A. It is not. After all, there is always time, and when there is time there is cracking, when a cracking temperature is applied. So that there will always be a trace of cracking.

Q. If you said no decomposition prior to vaporization you would be defining an operation that could not be attained at all? A. That is correct.

The Court: Is cracking synonymous with vaporization?

Mr. Forward: No, your Honor. Cracking is a chemical decomposition. Vaporization is a mere

change of phase, like from water to steam. It is still H_2O . It can be condensed back into water. Cracking is a chemical decomposition. You start with a relatively high molecular weight hydrocarbon oil. It has a fairly high boiling temperature. You subject it to this heat and pressure and you cause a chemical reaction, which is known as cracking or conversion. It is a decomposition. You generate from that high boiling oil a totally different hydrocarbon. It is now a smaller molecule which can be condensed back into a liquid which is low boiling and is used as gasoline. As a by-product of that reaction, the industry has heretofore regarded it as being necessary to have tar formed. In other words, the formation of tar has been a by-product of that cracking reaction.

The Court: You do not begin this decomposition process which you call cracking until you have vaporization? In other words, you cannot have cracking without vaporization. Am I correct in assuming that?

Mr. Forward: Oh, no, your Honor.

62 The Court: I want to clear my mind. Will you explain that?

The Witness: Cracking is the breaking down of a heavy oil such as kerosene and making gasoline out of it. The temperature can be as low as 700 degrees Fahrenheit, and at that temperature the oil may be liquid but it takes a much longer time to crack it than it does at a temperature in the neighborhood of 900 to 950 degrees. In commercial cracking processes the majority of the cracking is accomplished at around 900 to 950 degrees; and that is what they refer to sometimes as the cracking temperature, although some cracking or decomposition has taken place at the very low temperatures, around 700 degrees.

The Court: Decomposition sets in as a result of the application of some outside medium, which presumably is heat; is that right?

The Witness: Yes, sir.

Mr. Forward: But if the pressure applied is high enough you can keep it in liquid form even though you get the cracking, provided you are not above the critical temperature?

The Witness: That is correct.

The Court: And by pressure you mean the force that is used in putting oil, so to speak, into a coil where this process of vaporization and cracking ultimately goes on?

The Witness: That is correct, sir.

The Court: So that in order to have cracking you would have to have pressure plus heat?

The Witness: No, sir; that is not entirely correct. You could crack under vacuum, but it would hardly be practical.

63 The Court: I am talking about the practical application of it.

The Witness: The so-called low pressure units we operate at substantially atmospheric pressure.

By Mr. Forward:

Q. How does the rate of cracking reaction change with temperature, roughly? A. The cracking reaction doubles approximately with every 20 degree change in temperature.

Q. If you raise the temperature 20 degrees you roughly double the cracking rate? A. That is correct.

Q. And if you raise it 20 degrees more you double it again or make it four times as great? A. Yes.

Q. Because of that it is desirable to crack at fairly high temperatures so you can have the cracking reaction proceed quite rapidly? A. That is right.

Q. When you refer to the critical temperature to what do you refer? A. I refer to the temperature of the oil in the tube with just a trace of decomposition. It may be slightly different from the original oil, but it is approaching the critical temperature of the original oil that was charged through the still.

Q. I am simply asking for a definition of critical temperature. I think you misunderstood me. A. What is the critical temperature?

64 Q. Yes. A. The critical temperature is the temperature above which liquid will not exist.

Q. That is the definition that is generally applied when you are speaking of a single compound, is it not? A. That is correct.

Q. Does that apply generally where you have a mixture of compounds instead of a single compound? A. I would say it applies generally, yes. It is commonly accepted. There is a slight technical variation, but I do not think it applies here.

Q. Did you not just say that in your test work you found that even though you got to the critical temperature, when you had a slow rate of heating you did not get complete vaporization; and your definition of critical temperature was that it could not exist as a liquid at that temperature? What I am trying to get at, Mr. Smith, is your test work that you started out on and by which you were duplicating commercial operations, and by using moderately rapid but not sufficiently rapid heating rates you got some conversion before you reached the critical temperature, and you then found, according to your testimony, as I understand it, that when you reached the critical temperature you did not get complete vaporization. Would that test work indicate that the mixture that you have, after cracking has taken place to a significant extent, no longer obeys the usual laws with respect to critical temperature? A. That is correct. When decomposition has

taken place, then this tar formed by decomposition will not vaporize, even though you are at the critical temperature of your charge stock. That has been known in the industry for a long time and is a generally accepted theory.

Q. Will you regard to Gard patent 1,914,914 which has been cited in the answer in this case? I would like to ask you whether or not your process, as defined in your claims, is shown in that patent? A. No, sir.

Q. Just what does this patent disclose? A. This patent discloses that oil, if cracked at a pressure higher than the critical pressure which would prevent, according to their statement, vaporization up to the critical temperature, no carbon deposit would be formed. The patent makes an error in that it says that if the pressure is high enough then the oil will vaporize completely at the critical temperature, and disregards the time factor with respect to the temperature.

Q. I refer you to page 1, the second column and the last paragraph, and particularly the sentence starting on the third line from the bottom of the page and continuing over at the top of the next page. This patent at that point suggests that it is safe to assume that if your pressure is high enough you will get complete vaporization when you reach the original critical temperature even though there has been cracking. Does your test work confirm that assumption, or does it contradict it? A. Our test work contradicts this statement. It was generally believed that this was the case before this test work was done, but it is entirely false in view of what we have found out.

Q. I want to ask you one more question. If it were really true that the phenomena actually did occur which he tells you here will occur, a thing which he says it is safe to assume will happen, would there be any occasion to resort to the extremely rapid rate of heating which you employ in your process? A. No; there would not.

Q. If the facts were as he states them there would be no occasion to employ any exceptionally rapid rate of heating? A. No.

Q. Mr. Smith, this patent illustrates an apparatus in which there are two coil sections—

The Court (interposing): May I suggest that it is now 12:30, and we will reconvene at 2 o'clock. I assume you will be through with the direct examination shortly. I do not want to rush you. Of course I do not assume that you will be through in five or ten minutes.

Mr. Forward: I would say, in about twenty minutes, your Honor.

The Court: I think probably all of us would be much better off if we reconvene at 2 o'clock.

(Whereupon, at 12:30 o'clock p. m., a recess was taken until 2 o'clock p. m. of the same day.)

(After recess.)

(The proceedings were resumed at 2 o'clock p. m., at the expiration of the recess.)

Thereupon READING BARLOW SMITH, the witness under examination at the time of taking the recess, resumed the witness stand and was examined and testified further as follows:

Direct Examination (Resumed):

Mr. Forward: Just before we adjourned I believe we were talking about the Gard patent.

The Court: I think you had finished that. I am not quite certain. The reporter will know it.

Mr. Forward: I believe there was one more point that I wanted to raise with regard to the Gard patent.

The Court: I remember quite vividly, you were taking a diagram of the Gard patent, and you were asking questions about it, and then I asked you if you were going to take up more than ten minutes and that if you were we would adjourn.

Mr. Forward: Yes, sir.

By Mr. Forward:

Q. In this Gard patent the drawing illustrates an arrangement in which there are two parts to the furnace, and it is very well illustrated, I think, in Figure 5 of the patent. The oil enters through heating tubes of relatively large diameter; and it goes first through this first section, these tubes of large diameter, identified as 211 in Figure 5, and then goes through a coil made up of smaller tubes in the part of the furnace to the right, and it is
68 in there that the cracking is described as taking place.

Now, the Gard patent, if you will note, also describes the fact that this first part of the coil, which is of large diameter, is the part that is maintained under a very high pressure, and that as the oil passes to the second part of the heating coil where cracking is supposed to occur, or is described as occurring in the vapor phase, it is expanded and the pressure is reduced down almost to atmospheric pressure.

With such an arrangement what would be the relative times in the high-pressure and the low-pressure sides of the furnace—of the coil? A. I think the oil would be in the first part, the first heater, a much longer time than it would be in the second part.

Q. Both the relative diameters and the relative pressures would contribute in that direction, would they not? A. That is right.

Q. If you had any substantial cracking, any large amount of cracking, in the second section, would you have some cracking, some significant cracking, in the lower—in the high-pressure part of the furnace, with any such relationship of times? A. You certainly would. With the large time it would be in the high-pressure section and something in the neighborhood of 50% cracking throughout the whole heater, you would expect a large part of the cracking, a good percentage of the cracking, to have taken place in the high-pressure section.

Q. Is the arrangement shown such as would tend to effect any exceptionally rapid rate of heating in the high-pressure coil? A. No. On the contrary, you would expect a very moderate rate of heating in the high-pressure section.

Q. When you say "moderate" you are using that term in the relative sense, I assume, and comparing it with the very rapid rate of heating which you have to employ to take advantage of this phenomenon that you discovered? A. That is right.

Q. Now, as a practical matter, if you were going to modify this Winkler-Koch type of process so as to incorporate your discovery, how would you have to modify the procedure, if at all? A. I would modify the procedure by decreasing the time in the roof tubes, the heating section of that furnace, so that the time is very much less than the time encountered in a normal Winkler-Koch type still. At present it is hardly practical to decrease the time, since the tubes would be over-heated and tend to burn the tubes out, without some change in construction. One method of doing it would be to divide the heating tubes into parallel smaller heating tubes which would increase the relation of surface to volume and permit a great heat transfer and thus give more heating for a shorter time. That method has been suggested in the application.

Q. That is the arrangement that you illustrate in the application, your application drawings, is it not? A. It is.

Q. Then, procedurally the effect would be simply to increase the rate, that is, to materially increase the rate of heating in this bringing-up section? That is
70 the effect of it, dividing that coil into smaller tubes? A. Yes.

Q. Is that correct? A. That is correct.

Q. And that is the only modification that you need, and in every other respect the process could be carried out in the same way? A. Yes.

Q. And when you reduce the time or— A. (Interposing) Increase the rate of heating—

Q. —or increase the rate of heating— A. In those—

Q. —conversely, would that give the same result? A. Yes.

Q. That is, in the second and third tube banks? A. Yes.

Q. Mr. Smith, I should like to have you look at the decision of the Board of Appeals in this case, particularly that part that involves the description of the process of your claims, starting at the top of page 2, and tell me whether that is a correct statement of the essentials of the process of your invention. A. No, it is not a correct statement. This speaks of a cracking temperature, of decreasing the time, a minimum time to the cracking temperature; and my process speaks of a—or is the critical temperature.

Q. Is decreasing the time to the critical temperature?

A. To the critical temperature.

71 Q. Read a little further. This decision of the Board of Appeals suggests that the theory is “that the formation of pitch occurs at temperatures immediately below the cracking temperatures.” Is there any such theory involved in the application of your principle? A. No.

Q. Your process? A. No.

Q. Does the formation of pitch occur below the cracking temperature? A. No, it cannot occur below the cracking temperature.

Q. Is it correct to state that it does occur, if it occurs, above the cracking temperature but below the critical temperature? A. That is right.

Q. The critical temperature is considerably higher than the point at which you first begin to get cracking as your temperature is raised; is that correct? A. That is correct.

Q. Now, Mr. Smith, one more question along this line: This method of operation which avoids the formation of tar, it is my understanding, also avoids to some extent the formation of coke as well, but isn't it a major advantage to avoid formation of tar even if we disregard the question of coke? A. It certainly is. By avoiding the formation of tar you convert the oil to more useful and more valuable products. Therefore it is a distinct advantage to eliminate this lower-value product, such as tar is.

Q. Well, now, in these extensive operations of the Winkler-Koch still, in practice, they did make tar, didn't they? A. They certainly did.

Q. Considerable quantities of it? A. Yes, they did.

Q. In terms of the length of the run, over a long period of operation? A. You said tar?

Q. That is right. A. Yes, they produce tar.

Q. What is the average length of operation of a Winkler-Koch still? A. Approximately three months.

Q. And will you give a rough estimate of the approximate amount of oil which would pass through the still in that time? A. Well, about—

The Court: Well, I mean is that material?

Mr. Forward: I want to show the relationship, that in a normal operation they would make, over a period of three months' operation, thousands of gallons, thousands of barrels of tar.

The Court: And under this new process, the process in issue, that is eliminated?

Mr. Forward: Yes, that is eliminated.

The Witness: Well, roughly a quarter of a million barrels would pass through that heater inside of three months.

By Mr. Forward:

Q. And approximately what proportion of that would be made into tar? A. Ten percent.

Q. About ten percent of that many barrels of
73 oil would be made into tar.

The Court: Twenty-five thousand barrels of tar.

By Mr. Forward:

Q. Now, during that three months' operation how much carbon would be deposited in the heating tubes? A. The carbon would be approximately a quarter of an inch thick on, say, half the tubes; in those tubes, in terms of volume, in terms of weight, it would be insignificant compared to the tar formed.

Q. In these earlier operations of tube and tank type and in the Burton still, bulk still, they made a much higher proportion of carbon in their operations? A. Yes, they did.

Q. But the large formation of carbon had already been avoided by the Winkler-Koch type of operation? A. That is correct.

Q. But not the tar formation? A. That is correct.

Mr. Forward: Your Honor, I should like to take a few minutes, if the Court would like to have it, to have the witness explain just what occurs when you crack, as a chemical reaction.

The Court: You mean from the chemical standpoint?

Mr. Forward: From the chemical standpoint.

The Court: Well, I mean we know that now. As I understand it, when the cracking process begins there is a molecular decomposition; isn't that right?

Mr. Forward: That is it.

74 The Court: And the end product—that is, the terminal result from the standpoint of the new process—is gasoline that has been manufactured as a result of that process?

Mr. Forward: That is right.

The Court: And the result from the standpoint of economy of operation is the elimination of tar?

Mr. Forward: That is correct.

The Court: And carbon. Not so much carbon in this particular process, because that has been eliminated previously?

Mr. Forward: Very nearly.

The Court: But particularly of carbon?

Mr. Forward: Particularly of tar.

The Court: I mean of tar.

Mr. Forward: That is correct.

The Court: I am rather intrigued by the formula on the board. If you want to explain it off the record, you do not need to encumber the record. If Mr. Cochran will bear with me, I am curious about it.

Mr. Cochran: Well, I knew your Honor had asked the witness to explain what cracking was, and I thought that perhaps that would be a way of doing it.

The Court: Then let us put it on the record.

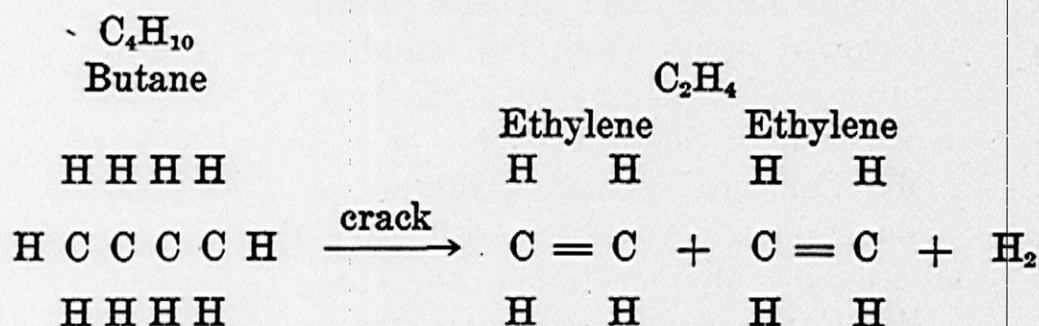
Mr. Forward: It is Mr. Cochran's suggestion.

The Court: Oh, it was Mr. Cochran's suggestion?

Mr. Cochran: I knew your Honor had inquired about cracking, and I did not know whether the witness had made it perfectly clear or not.

The Court: I would be more than pleased to have it demonstrated from the standpoint of mathe-

75 matical or chemical formulae; so if that is it (referring to formula on blackboard) I shall be very glad if the witness can explain it.
(The formula referred to is as follows:)



By Mr. Forward:

Q. Would you explain just what occurs, referring to the chemical formula, when cracking takes place? A. I have shown on the board a simple hydrocarbon molecule, a small one, butane, with four carbon atoms. We crack that; heat it.

Q. Yes? A. That can be heated in just a simple retort.

By the Court:

Q. Now, "H" means heat? A. "H" means hydrogen. "C" means carbon.

The Court: Well, that is what I want to know.

By Mr. Forward:

Q. This material is heated? A. That material is heated. The compound is composed of carbon and hydrogen. That whole string is butane. Heat is applied to that, and it breaks up. Instead of one molecule having four
76 carbon atoms, it breaks up into a molecule having two carbon atoms and another molecule having two carbon atoms. In other words, that is split, this four (indicating).

By the Court:

Q. Split it in two? A. In two. And in that case the product is ethylene. It is a very simple illustration.

By Mr. Forward:

Q. It is a very simple illustration of what takes place in cracking, this being a compound, butane, which would sometimes be written C_4H_{10} .

Mr. Fisher: H_{10} .

Mr. Forward: No. You are correct: H_{10} . I am sorry.

The Witness: Carbon and hydrogen.

The Court: That would be four atoms, then, of carbon and ten atoms of hydrogen: that is butane?

The Witness: That is right.

Mr. Forward: That is right.

By Mr. Forward:

Q. And in the ethylene there are two carbon atoms? A. Two.

Q. And four hydrogen atoms? A. Four hydrogen atoms, and that is written C_2H_4 .

By the Court:

Q. In other words, if you break butane by that proceeding into its constituent elements you get two elements known as ethylene? A. That is correct, your Honor.

77 Mr. Forward: That is right, and residual hydrogen is left over.

The Court: Well, I am very glad that this explanation has been made. It was very helpful.

Mr. Forward: Thank you. I believe that is all.

Cross Examination by Mr. Cochran:

Q. Mr. Smith, isn't it true that in the Gard patent and in the Peck patent the temperatures and pressures employed are comparable to those employed in your method? In both cases the temperature is above the critical temperature, and the pressure is above the critical pressure? A. That is correct.

Q. How about the Howard and Loomis patent? A. The Howard and Loomis patent, the temperatures are lower than the temperatures we are talking about.

Q. They are not so far below, though, are they? That is to say, they are within a hundred degrees Fahrenheit? A. Yes, but it is still below the critical.

Q. Below the critical? A. Below the critical.

Q. However, the others do have the critical temperature and critical pressure? A. Yes, sir.

Q. Isn't it true that in all three of these patents the statement is made that it is advantageous to heat the oil rapidly to begin with? A. Yes, the statement is made that the oil is heated rapidly, but not rapidly with respect to what I am talking about.

Q. Not as rapidly as you heat it. Well, isn't that the purpose stated in those patents for heating the oil rapidly, to avoid the formation of carbon or coke, or some such material as that? Isn't that the purpose of rapid heating? A. Yes, they state that by—I am not sure that the Gard patent says that is their purpose, but the patent is to prevent formation of carbon.

Mr. Cochran: I think that is all I care to ask.

Mr. Forward: Might I just ask one more question?

The Court: Yes.

Re-direct Examination by Mr. Forward:

Q. Isn't it true, however, that both Gard and Peck appreciate that they don't avoid the formation of tar, and

don't they both describe the formation of tar? A. That is correct. Not only do they both not say that they do not form tar, but they describe methods of even handling the tar that is produced and in fact go into rather quite a bit of detail on how to handle this tar that is produced; while I am speaking of not ever forming any tar, and therefore nothing has to be arranged to take care of it after it is formed.

Mr. Cochran: May I ask a few questions more on that line?

The Court: Yes.

Re-cross Examination by Mr. Cochran:

Q. Consider now the Gard patent. I notice that he says on page 1, beginning in line 93, that "The critical
79 temperature of the oil is changed by heating, for, in bringing the oil to the critical temperature some incidental cracking may occur * * *." Doesn't that indicate and teach that the decomposition which you do in cracking is only incidental and not substantial in his method?

The Witness: Would you mind repeating your question again, please?

Q. The last part of the question was: Does not that sentence indicate and teach that the amount of decomposition or cracking is only incidental and not substantial, not in substantial amount? A. If you quit reading there possibly you could draw that conclusion, but if you take the very next sentence then he refutes that. He states there that regardless of time, if you have the pressure high enough, the oil will be vaporized and entirely in the vapor phase.

Q. And does that not mean that there was no tar formed in the heating, if it is entirely in the vapor phase? A. Yes,

that would mean that, but that is where I believe he has erred, because he didn't recognize, and probably very few did, until after we made this experiment when we found out, that time did influence the amount of liquid you have present. Up until these experiments we made, it was assumed that you would have vapor, just as he states it, but the actual facts of the case are: you don't have vapor; you will have some liquid unless you control this time period.

Further Re-direct Examination by Mr. Forward:

Q. I would like to ask a question, because I don't think that the previous reference to a comparison between "incidental" and "substantial" is a fair comparison,
80 because they are not opposites, nor the same thing either. They are not related.

If you heat slowly, moderately slowly, up to the critical temperature, and then do a considerable amount of cracking, a very large amount, after you get there, you may have a very substantial amount of cracking also occur before you get to the critical temperature? A. That is correct.

Q. But would not that cracking which did occur before you reached the critical temperature be merely incidental to that particular rate of heating which you employed, whether it was slow or fast? A. Yes.

Q. It would be an incident of heating at the particular rate employed? A. Yes.

Mr. Forward: Your Honor, I should like to correlate myself a little bit on this and submit a brief. Would that be acceptable, your Honor?

The Court: Well, that is acceptable to the Court if it is acceptable to the Government.

Mr. Cochran: Yes.

Mr. Forward: How much time would you like to have? How much time may we have?

The Court: We usually like to get these things disposed of as quickly as possible. The Court has a rather selfish point of view in mind, because the quicker I get the brief while the matter is fresh in my mind the quicker I can dispose of it.

81 Mr. Forward: If we have the briefs in within ten days will that be sufficient?

The Court: I would suggest ten days, if it is all right.

Mr. Forward: That will make us move pretty fast even so, but we will try to do it within ten days.

EVIDENCE ON BEHALF OF THE DEFENDANT.

Mr. Cochran: May I offer in evidence, your Honor, the defendant's exhibit, which consists of a copy of each of the following:

The Gard patent, No. 1,914,914;

The Peck patent No. 1,933,507;

The Howard and Loomis Patent, No. 1,869,337;

A publication by McKee on "Critical Temperatures and Oil Cracking";

A print of drawings of the plaintiff's application;

A copy of the Examiner's statement; and

A copy of the decision of the Board of Appeals of the Patent Office?

The Court: That may be done.

(Document produced by Mr. Cochran was marked Defendant's Exhibit No. 1 and received in evidence.)

Mr. Forward: Perhaps I should ask one more question in view of that offer of the McKee article.

82 EVIDENCE IN REBUTTAL IN BEHALF
OF THE PLAINTIFF.

Thereupon READING BARLOW SMITH was recalled as a witness for and on behalf of the plaintiff in rebuttal and, having been previously duly sworn, was examined and testified further as follows:

Direct Examination by Mr. Forward:

Q. Have you read this McKee article which was cited against your case? A. I have.

Q. With the oil sample that you have tested in these various tests that you have made and testified about, on the basis of the McKee article what would the critical temperature of that oil sample be? A. We would calculate that it would be about 932 degrees Fahrenheit.

Q. 932 degrees Fahrenheit. And do your investigations indicate that that is a reasonable approximation of the critical temperature? A. I would say it was somewhat low. My investigations show that the critical is close to 945, 950, and McKee also states that, explains that that is very likely, in his method of calculating the critical.

The Court: Ten days are satisfactory to you, Mr. Cochran?

Mr. Cochran: Yes, sir.

83 The Court: I might say, the Court will not penalize you if you have to go over a day or two. I have two patent cases now, as you know, that are still under advisement, and this will make the third. I do not like to have them accumulate on me.

(Whereupon, at 2:25 o'clock p. m., the trial was concluded.)

From Plaintiff's Exhibit 1
SPECIFICATION
of
UNITED STATES PATENT APPLICATION
of
READING BARLOW SMITH
For: CONVERSION OF PETROLEUM
Serial No. 194,776 Filed March 9, 1938

88 My invention relates to improvements in the conversion of higher boiling petroleum oils to lower boiling petroleum oils, particularly in the production of motor fuel gasoline.

I have discovered that petroleum stocks can be cracked without substantial formation of pitch if the stock is completely vaporized prior to any substantial decomposition of the stock and the stock is then cracked following complete vaporization without antecedent decomposition.

The formation of pitch, an apparently inevitable incident of cracking as hitherto practiced, has been the underlying cause of most of the major difficulties encountered in the development of cracking processes for more than twenty years. The "carbon" problem, for example, has consisted largely of the difficulties involved through decomposition of such pitch and consequent formation of insoluble carbonaceous solids and semi-solids.

The advances made by the practical art with respect to the "carbon" problem have been the result of attack upon these several incident difficulties rather than upon the underlying cause, the formation of pitch. For example, the more important advances have involved the limitation of pitch concentration within parts of the cracking apparatus, the avoidance of local overheating in parts of the

apparatus where pitch is formed or present and provisions to limit deposition of solid and semi-solid products of decomposition of pitch to special parts of the apparatus.

My invention, however, deals with the formation of pitch rather than with its consequences.

In carrying out my invention, I heat the higher boiling oil to vaporize it and thereafter heat it to crack it while maintaining a pressure exceeding the critical pressure on the oil through the point of vaporization, and I heat the oil prior to the point of vaporization at a rate
89 high enough to prevent substantial decomposition prior to this point by limitation of the time factor.

The oil being under a pressure exceeding the critical pressure through the point of vaporization, it vaporizes at the critical temperature. Under these conditions the vaporization is substantially instantaneous, that is it occurs substantially at a point. Thus, decomposition prior to complete vaporization is substantially avoided. In referring to "critical pressure" and "critical temperature", I refer to the critical pressure and critical temperature of the oil mixture.

In the so-called "liquid phase" processes hitherto practiced, substantial decomposition of unvaporized stock inevitably occurs. Thus, even though high pressures are used, pitch is formed. In the so-called "vapor phase" processes hitherto practiced, pressures less than the critical pressure have been used, and even though relatively high pressures have been used in some instances the rate of heating has not been high enough to prevent substantial decomposition prior to complete vaporization. Consequently, stock undergoing vaporization is subjected to decomposition before vaporization is complete and pitch is formed. In the so-called "mixed phase" processes hitherto practiced, the bulk of the decomposition is effected while the stock is partially vaporized and partially unvaporized and pitch is formed. Continued cracking of stock mixtures containing the pitch formed by decomposition antecedent

to complete vaporization, in any of these processes, produces "carbon" and coke. My invention avoids the original formation of pitch.

90 In the production of gasoline from Midcontinent gas oil, for example, in accordance with my invention, I may heat the gas oil stock to a temperature of 920°-980°F., from a temperature below that at which substantial decomposition begins, in from [2 to 2.5 seconds]* 1 to 2 minutes (RBS 3-2-28) while maintaining a pressure on the stock through the point at which it reaches that temperature upwards of 800-1200 pounds per square inch and then, while maintaining or moderately increasing the temperature, I continue the cracking until the increment of fractions 90% of which boil off up to 392°F. at atmospheric pressure approximates 25%-30%. The precise temperature, time and pressure used in any particular case will of course depend upon the stock being processed, its properties in the respects previously stated. The percentage crack per pass through the heating and cracking operation, the increment just specified, should in general be limited to about 25%-30% if substantial formation of pitch is to be completely avoided.

Apparatus in which the process of my invention may be carried out is illustrated, diagrammatically, in the accompanying drawing. The stock to be cracked, supplied through connection 1, is forced, by pump 2, through the successive heating sections 3 and 4, under pressure maintained and regulated by valve 5. The hot cracked products are discharged through connection 6. A cooling medium to bring the temperature of these products to a temperature below that at which active cracking occurs within a minimum time, supplied through connection 7, is forced, by pump 8, into connection 6 in direct heat exchanging relation with the hot cracked products discharged from the second heating section. Otherwise, conditions involving pitch formation may occur as the temperature falls

*Words and figures enclosed in brackets erased in copy.

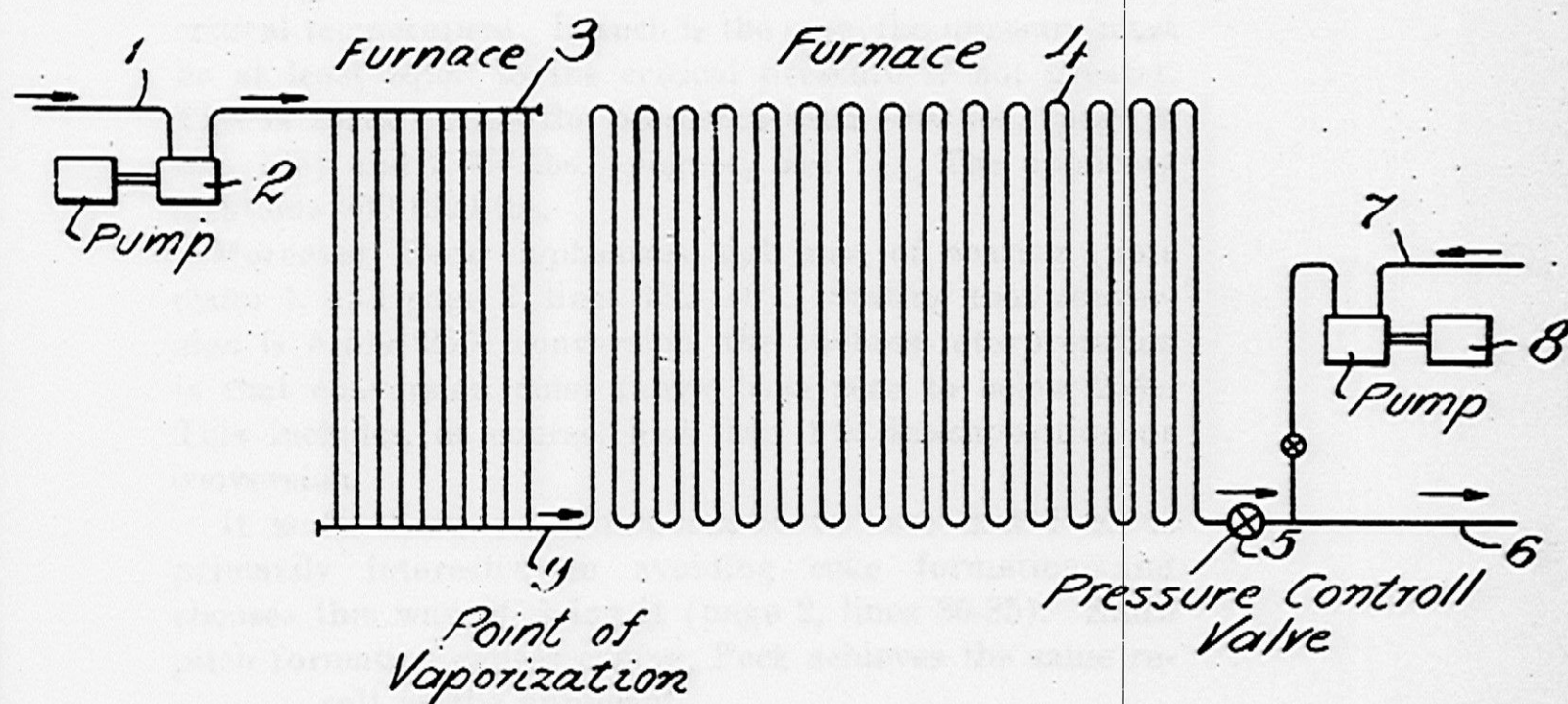
91 from the cracking temperature just as they ordinarily occur as the temperature rises to the cracking temperature. The heating tubes making up the heating section 3 are connected in parallel, to promote rapid heating in this section. Those making up section 4 are serially connected to limit the rate of heating in this section. The tubes of section 4 may be of larger internal diameter than those of section 3. Section 3 and section 4 are so proportioned that complete vaporization of the stock occurs about at point 9. These two heating sections may be arranged in a single furnace or, to facilitate control, they may be arranged in separate furnaces. The stock supplied to connection 1 may be preheated to a temperature short of that at which substantial decomposition begins to reduce the heating burden in section 3. The hot cracked products discharged through connection 6 may be delivered to conventional fractionating equipment. Appropriate fractions may be returned from such fractionating equipment to connection 1. The stock supplied to the heating and cracking operation should itself, of course, be free from pitch.

In avoiding the formation of pitch, my invention represents an important improvement in the conversion process as an operation. Of corresponding importance, it also avoids the formation of residual products of relatively low value because of their content of pitch or insoluble carbonaceous solids and semi-solids.

92 I CLAIM:

1. The process for conversion of higher boiling petroleum oils to lower boiling oils which comprises heating the higher boiling oil to vaporize it and thereafter to crack it, maintaining a pressure exceeding the critical pressure on the oil through the point of vaporization and heating the oil prior to vaporization at a rate high enough to prevent substantial decomposition prior to vaporization.

2. The process for conversion of higher boiling petroleum oils to lower boiling oils which comprises heating the higher boiling oil to its critical temperature and thereafter to crack it, maintaining a pressure exceeding the critical pressure on the oil through the point at which it attains its critical temperature and heating the oil prior to this point at a rate high enough to prevent substantial decomposition prior to this point.



INVENTOR
Reading Barlow Smith
 BY
Bennie Davis Mawin & Edmonds
 ATTORNEYS

Paper No. 5

March 1, 1939

95 Responsive to argument filed November 29, 1938.

Claims 1 and 2 are rejected as unpatentable over the references and for the reasons of record.

Peck has disclosed cracking in the critical range of temperature and pressure (page 2, lines 76-80). It is obvious that if Peck operates to secure what he calls homogeneous cracking, no vaporization can occur prior to reaching the critical temperature. If such is the case, the pressure must be at least equal to the critical pressure if not greater. This is borne out by the pressures used—900 lbs. (page 3, line 135) and 2,460 lbs. (page 4, line 7). The applicant mentions 800-1200 lbs.

Moreover, Peck emphasizes high rate of heating (note claim 1, and page 2, lines 132-140). Stating that conversion is *below* 25% conversion, the obvious interpretation is that conversion must range from zero to below 25%. This includes, of course, less than 1% decomposition or conversion.

It is furthermore of importance to note that Peck is primarily interested in avoiding coke formation and chooses this way of doing it (page 2, lines 30-35). Since pitch formation causes coking, Peck achieves the same result as the applicant.

96 Of equal weight to Peck, the patent to Gard discloses cracking under critical pressure to the point beyond the critical temperature—with low tar formation (page 1, lines 18-20). The ratio of heating is rapid (claim 8, and page 3, lines 83-84), and during the time the oil is in the liquid phase (below critical) it is merely heated to the cracking temperature (page 1, lines 31-33). Gard emphasizes this point by referring to the vapor phase zone as the cracking zone and underlines this by indicating that cracking before reaching the critical state is incidental.

This rejection is made FINAL.

Examiner.

Appeal No. 32,276 Hearing: March 13, 1940

97

IN THE UNITED STATES
PATENT OFFICE.

BEFORE THE BOARD OF APPEALS.

Ex parte Reading Barlow Smith.

Application for patent filed March 9, 1938, Serial No. 194,776. Conversion of Petroleum.

Messrs. PENNIE, DAVIS, MARVIN & EDMONDS for applicant.

This is an appeal from the decision of the examiner finally rejecting claims 1 and 2.

The following claim is representative:

1. The process for conversion of higher boiling petroleum oils to lower boiling oils which comprises heating the higher boiling oil to vaporize it and thereafter to crack it, maintaining a pressure exceeding the critical pressure on the oil through the point of vaporization and heating the oil prior to vaporization at a rate high enough to prevent substantial decomposition prior to vaporization.

The references relied upon are:

Gard	1,914,914	June 20, 1933
Peck	1,933,507	Oct. 31, 1933
McKee	"Critical Temp. and Oil Cracking"; Ind. and Eng. Chem.; Vol. 20, No. 11; Nov. 1928; pp. 1169-1172.	

98 The Appealed claims relate to a process of converting higher boiling petroleum oils to lower boiling oils by a cracking operation. The appealed claims are concerned especially with the feature of bringing the higher boiling oils quickly to the cracking temperature,

and it is based on the theory that the formation of pitch occurs at temperatures immediately below the cracking temperatures. In order to keep the formation of pitch at a minimum, it is essential that the raw product be brought quickly to the cracking temperature and after cracking, the product should be rapidly cooled. The cooling operation can easily be accomplished by quenching with cold oil, but the heating feature presented some difficulty. Appellant brings his higher boiling oils quickly up to the critical temperature of the oil while maintaining it at a pressure above the critical so as to prevent any vaporization before the critical temperature is reached. This is done by passing the material through a series of pipes arranged in parallel in an oven.

It may be said here that it is deemed impossible at least on a commercial scale to completely avoid the formation of pitch in the cracking of petroleum oils. This, in effect, is admitted here in that both claims state that appellant's process will prevent "substantial" decomposition.

The patent to Gard discloses a method of cracking oil which is quite like that claimed. In this patent the pressures and temperatures maintained in the oil heating stage are substantially the same as disclosed in this application. In carrying out the method disclosed in this patent the oil

99 in the first stage is brought up to the critical temperature without any vaporization. It is admitted that no claim is made in this patent of the fact that no pitch is formed during this preliminary heating step, but on page 3, lines 83-84 it is stated that the heating is rapid. After passing through the cracking chamber of the heater the product is quickly quenched to bring its temperature below the cracking temperature by the introduction of coal oil in the same manner as in appellant's process.

We are of the opinion that in carrying out the operation defined in this patent, practically the same results will be obtained as with appellant's process. It is probable that

in both cases some pitch will be formed during the liquid heating stage and the difference will be one of degree only.

It is not deemed necessary to discuss the patent to Peck in detail for the reason that it does not seem so pertinent as the patent to Gard et al. This patent shows only one stage of heating where the oil is both brought up to cracking temperature and then held at such temperature while cracking occurs. The product is then discharged into a soaking chamber where further cracking undoubtedly takes place.

However, we agree with the examiner that there is no substantial difference between the process claimed and that disclosed in the patent to Gard et al., and the decision of the examiner is, therefore, affirmed.

EUGENE LANDERS,	}	Board of Appeals
Examiner-in-Chief.		
F. P. EDINBURG,		
Examiner-in-Chief.		
C. H. SHAFFER,		
Examiner-in-Chief.		

Messrs. PENNIE, DAVIS, MARVIN & EDMONDS,
165 Broadway,
New York, N. Y.

March 25, 1940.

PLAINTIFF'S EXHIBIT 2

(Pages 332 and 333 from Cross Handbook.)

332

CRACKING

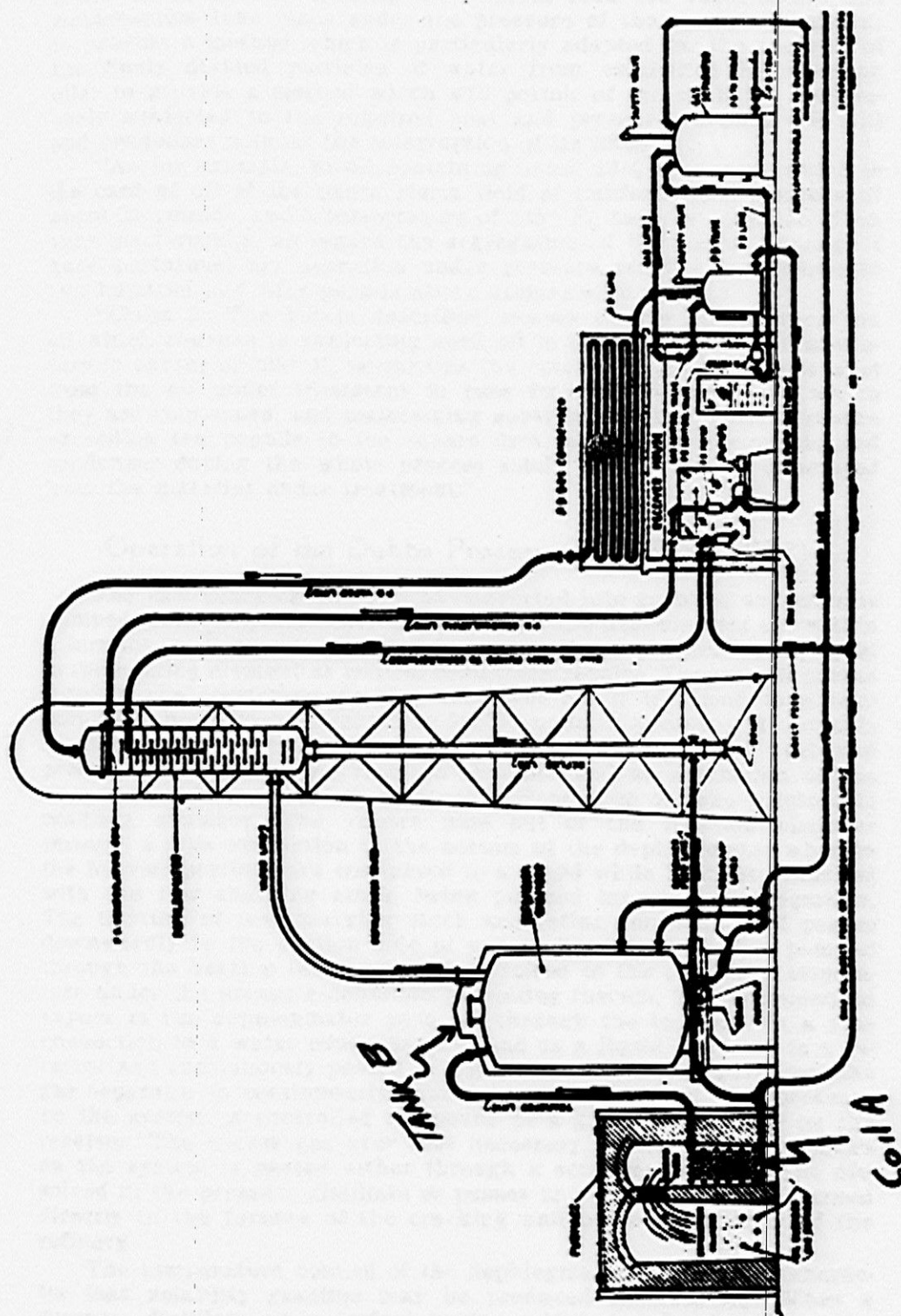
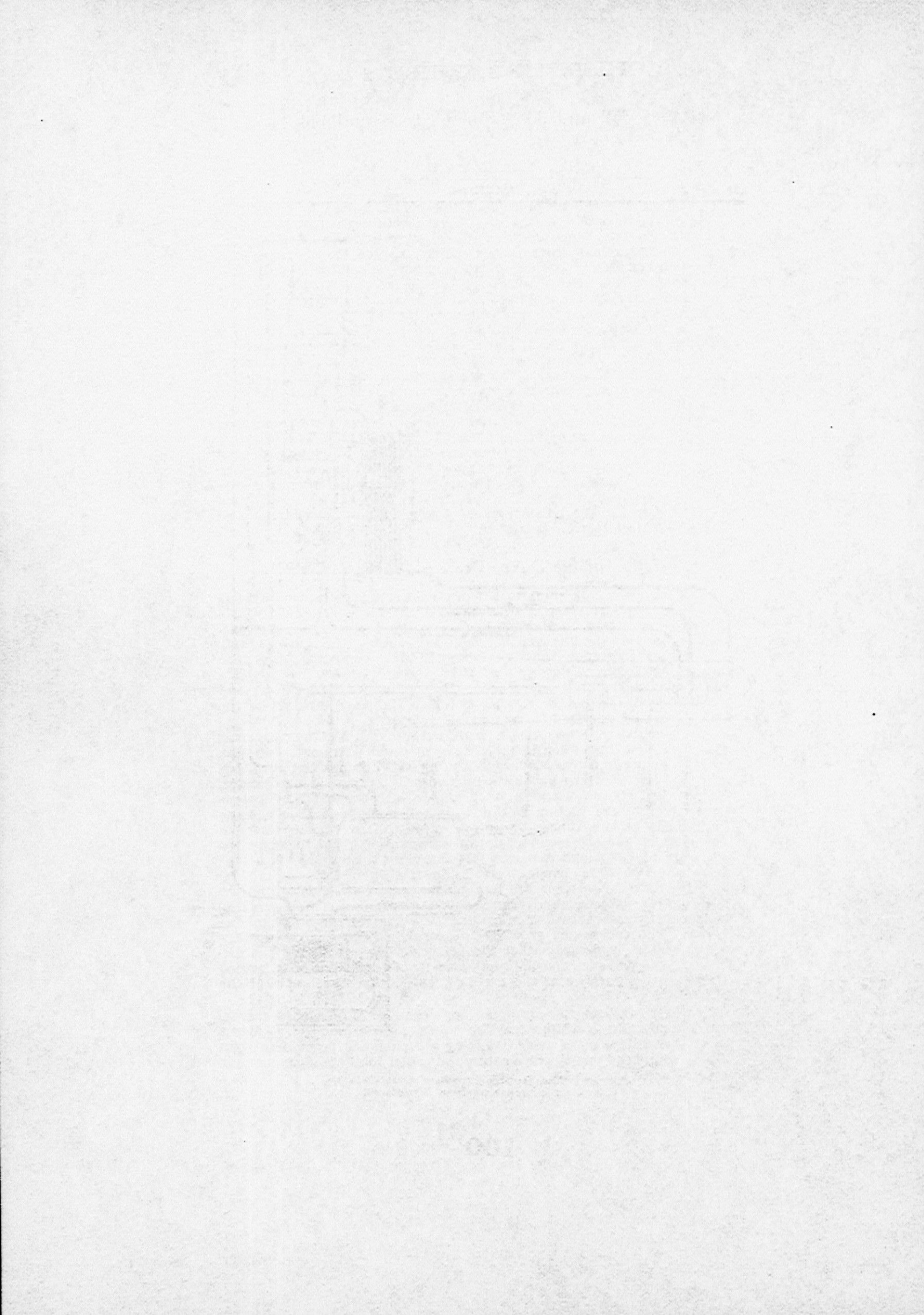


Fig. 80—The Dubbs Pressure Distillate Cracking Process as Now Practiced



"Among the salient objects of the invention are to provide an improved method of treating oil wherein both the vaporization and condensation take place under the pressure of the generated vapors; to provide a method which is particularly adapted for the removal of the finely divided particles of water from emulsified hydrocarbon oils; to provide a method which will permit of the oil being continuously subjected to the required heat and pressure in both the still and condenser without the interruption of its flow. . . .

"As for example, in oil containing about 28% of water (which is the case of oil of the Santa Maria field of California), a pressure of about 25 pounds, and a temperature of 325° F., more or less, has given very good results, as regard the segregation of the water, although I have performed my operation under pressure ranging from three to two hundred and fifty pounds above atmospheric. . . .

"Claim 9. The herein described process of treating hydrocarbon oil which consists in subjecting such oil in a receptacle to a temperature in excess of 300° F., permitting the volatilized products generated from the oil under treatment to pass freely to a condenser where they are condensed, and maintaining substantially the entire pressure exceeding ten pounds to the square inch in both the receptacle and condenser during the whole process solely by the vapors generated from the material under treatment."

Operation of the Dubbs Process (G. Egloff, 1927)

The raw charging stock to be converted into gasoline and coke is pumped to the dephlegmator or directed to the heat-element set within a furnace, or it may be diverted in part to the dephlegmator and part to the heating element as control conditions require. The raw oil passes through the continuous heating tube wherein it is raised to a temperature approximately 820°F. to 900°F. under a pressure of upwards of 200 pounds to the square inch. The heated oil under heat and pressure passes into the reaction chamber and as a function of the temperature is vaporized therein with a deposition of coke within said reaction chamber. The vapors pass out of the reaction chamber through a pipe connection to the bottom of the dephlegmator wherein the heavier portions are condensed to a liquid while heat interchanged with the raw charging stock, being pumped into the dephlegmator. The mixture of raw charging stock and reflux condensate oil passes downwardly to the suction side of a hot oil pump, and then pumped through the heating tubes. The oil is raised to the cracking temperature under the pressure condition prevailing therein. The uncondensed vapors in the dephlegmator pass out through the top and via a pipe connection to a water condenser coil and as a liquid collected in a receiver and continuously passed to a gas separator. The liquid from the gas separator is continuously passed to a storage tank. The pressure on the system is controlled by means of a gas release valve on the receiver. The excess gas over that necessary to control the pressure on the system is passed either through a scrubber with the gas dissolved in the pressure distillate or passes to a gas holder or is burned directly in the furnace of the cracking unit or in other parts of the refinery.

The temperature control of the dephlegmator is of such a character that volatility gasoline may be produced continuously. When a pressure distillate oil is desired having a higher end point than volatility gasoline the temperature control on top of the dephlegmator may be adjusted to that end.

PLAINTIFF'S EXHIBIT 3

(Pages 322, 324 and 325 from Cross Handbook.)

322

CRACKING

The Cross Process

Fifteen years ago the yield of gasoline of 25% by cracking was considered the most that might be expected, and ten years ago a 40% yield was quite unusual, while today 80% is quite usual, using high pressure cracking at 700 pounds and 850° F. temperature. An illustration of this fact is borne out by the following summary of the guarantee and performance of a standard Cross cracking unit:

	Guarantee	Performance
Stock: Fresh Gas Oil not over.....	50%	48%
Recycle stock at least.....	50%	55%
Hours on stream.....	144	167
Gasoline yield.....	80%	79.9%
Gasoline yield once through without refluxing or recycling.....	30%	43.2%
End point of gasoline.....	437° F.	434° F.
Barrels per day per unit on stream.....	600	399
Barrels charge per run.....	12,000 minimum	14,450
Liquid fuel.....	2% maximum	Gas only
Recoverable products.....	96% minimum	97.4%
Fuel oil—carbon sediment.....	Below 1%	0.2%
Viscosity (at 100° F Saybolt U).....	Marketable	32 seconds

Originally the operation of the Cross process was as follows: (See fig. 77.)

Normally the charging stock is 32-36° B₆ gas oil. This gas oil is taken in by pump (1) through the intake line (30), from which it is discharged through line (24), valve (28) being closed and valve (29) being open. The oil then passes through the heat exchange coil in the dephlegmator tower (17) in which coil it is raised to a temperature of approximately 350° F.

It is then discharged out through the line (23) into the upper coils of the furnace (3). The oil passes downward through this coil, then out of furnace and to the bottom of the coil (4). Heat is applied in the furnace (5). The oil passes upward in the coil (4) and out through the line (7), the temperature (normally 850° F.) being recorded by thermometer (8).

Since this oil is under a pressure of approximately 600 pounds per square inch, much less heat is actually required to effect cracking than if a lower pressure were used with resultant loss of most of the heat by vaporization. This point is fundamental and must be understood in order to understand the Cross process. As the oil passes from line (7) into the reaction chamber (9) there has been very little conversion into gasoline. The conversion takes place in the reaction chamber (9) where the oil is held for a period of at least 15 minutes, and all free carbon which is formed in the cracking reaction is here deposited as coke.

This reaction chamber is not externally heated, but is thoroughly insulated to prevent any appreciable loss of heat to the atmosphere. It is a solid steel forging with walls three inches thick and without welds or rivets. Practically all of the drop in temperature in this reaction chamber which amounts to about 100° is caused by the cracking effect desired. The normal conversion is about one-third of the oil under treatment, this being approximately ten times the conversion that would take place if the oil were allowed to vaporize directly from the reaction zone at a pressure of 100 pounds.

The oil together with any gas that may be formed is discharged as hot synthetic crude out through the line containing the valve (12). This valve is the only control required for the pressure as the liquid

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level is self-maintained at the level of the outlet from the reaction chamber. This valve is normally set so that very little attention is required, often going for many hours without any adjustment.

The hot synthetic crude is now discharged into the vaporizer or still (13) which is maintained at almost atmospheric pressure. In the case of gas oil 90 per cent is distilled with a 10 per cent fuel residue. The fuel oil level in vaporizer (13) is controlled by the level regulator (15). This residue discharges out by line (25) through cooler to fuel oil storage.

A special mist separator (16) is inserted so that the gas, synthetic benzine and recharging stock all pass as a clean vapor into the tower (17). In this tower, which is of special patented construction, the recharging stock is condensed and maintained at a level controlled by level regulator (32).

The recharging stock which consists of kerosene and gas oil products is discharged out through line (31) through a coil in box (19) and out through the line (27) to recharging stock or gas oil storage from which it is again used as charging stock for the plant.

The synthetic benzine, together with the fixed gas, passes out through the line (18) into the condenser coils in the box (19). From here it passes into the gas separator (20), the synthetic benzine going out through line (22) and the gas may be put through an absorber to remove the last portion of gasoline from it. This gas usually carries some very light gasoline unless absorbed out.

The gas from this separator is fired in the furnace (5) and after the plant is on stream constitutes sufficient fuel to keep up the operation. The furnace temperature is normally 1350 degrees F.; the stack temperature is normally 600 degrees to 650 degrees F.

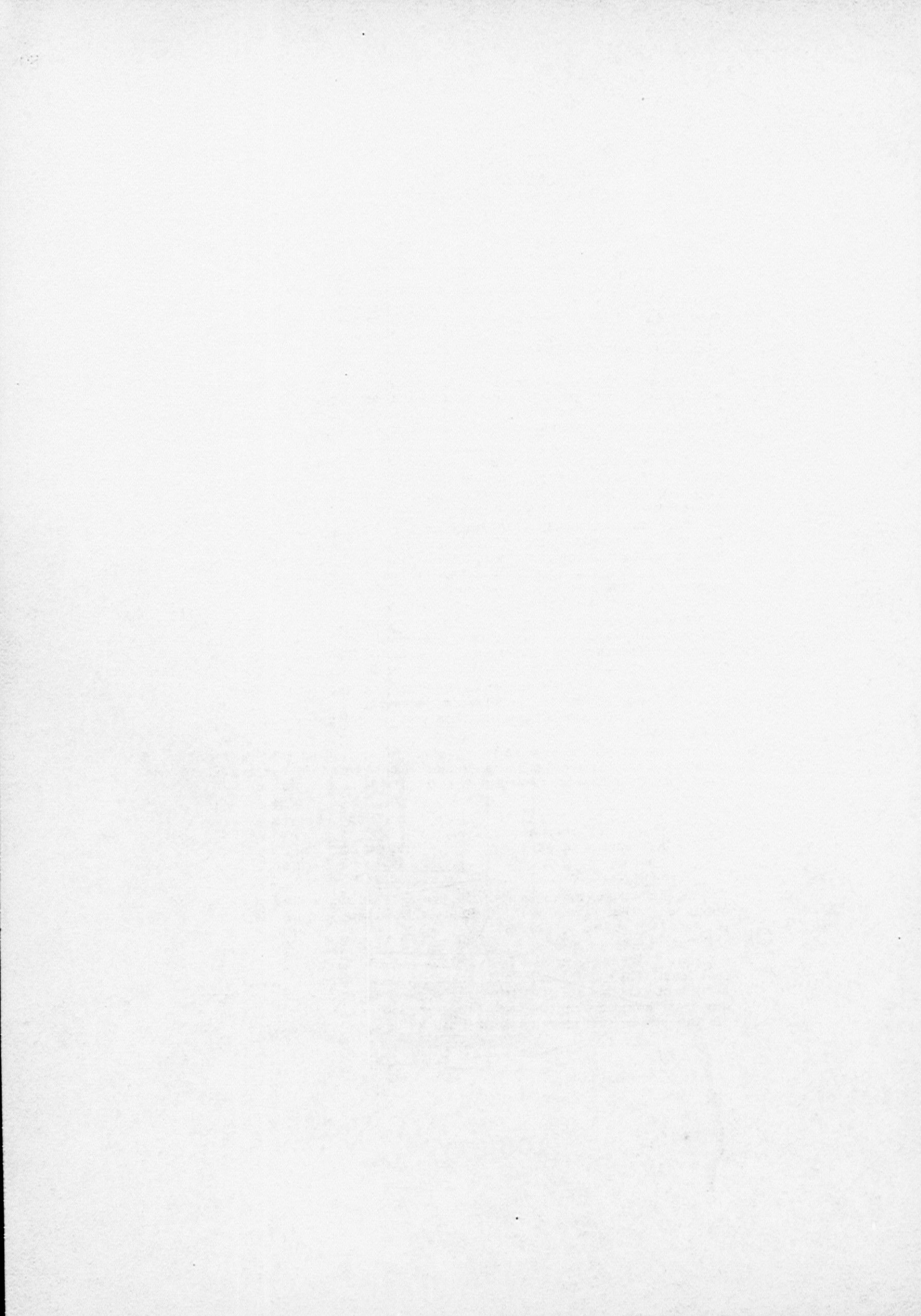
The benzine or gasoline from line (22) in the plants using a "spiral" tower shown in the diagram is treated and rerun to give 60% to 70% of finished gasoline, the residue being used again for charging stock.

In present plants, however, a "bubble" tower is used which gives gasoline of the desired distillation range without rerunning. A typical yield without refluxing, recycling or rerunning is as follows:

	Without Recycling	With Recycling
End Point gasoline.....	35.0%	70%
Recharging stock	52.0%	
Fuel oil	10.0%	23%
Loss	3.0%	7%

In each cycle, approximately 50 per cent of recharging stock is obtained so that normally the ultimate recovery of gasoline is twice the recovery shown by one cycle.

The standard plant as shown in this sketch, contains 90 tubes, 3 inches I. D. and 4 inches O. D. in the furnace, each tube being 24 feet long. The plant while on stream produces normally about 350 barrels of gasoline per day from gas oil, 400 barrels of gasoline per day from kerosene, or 400 barrels of gasoline per day from fuel oil (In the case of fuel oil a small pipe still is used in conjunction.)



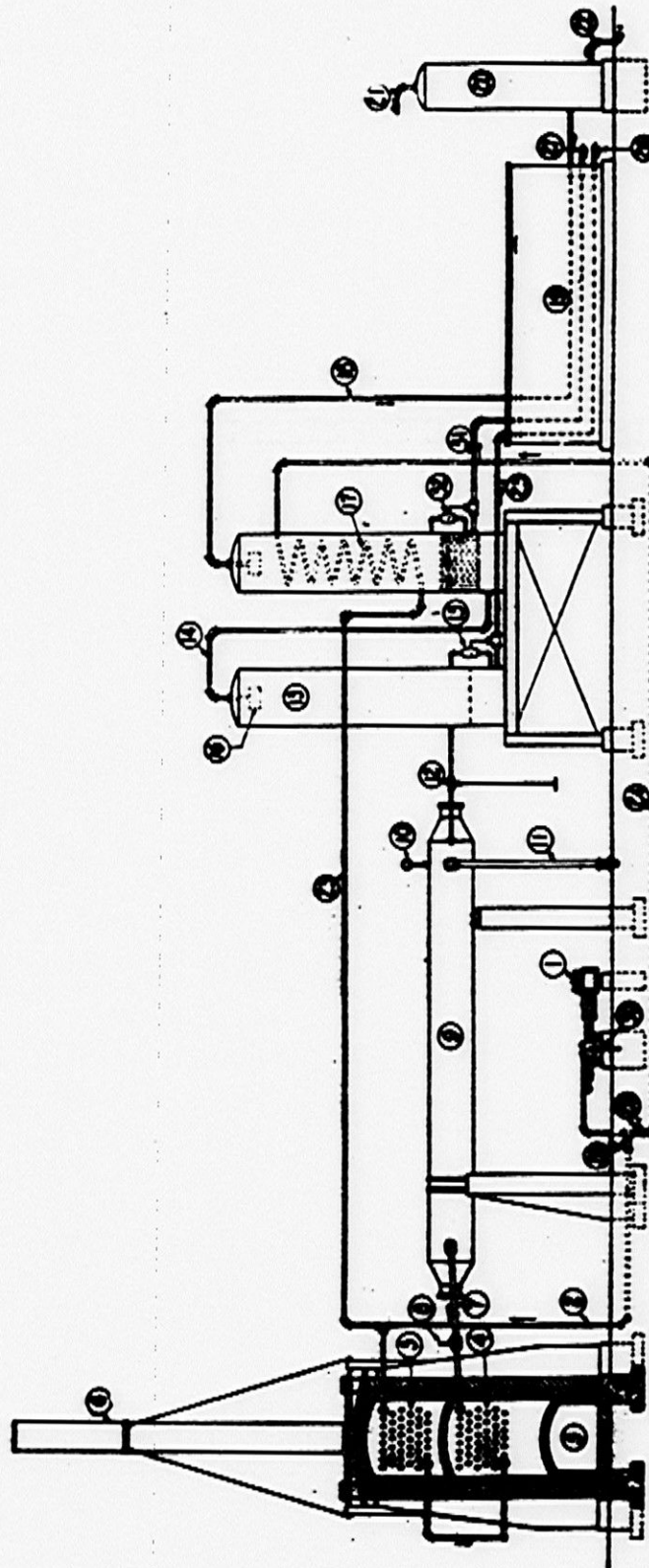


Fig. 77—Diagram of the Operation of the Cross Process Treating 1,000 Barrels of Total Oil or 500 Barrels of New Oil per Day and Producing 800 to 400 Barrels of Gasoline per Day.

PLAINTIFF'S EXHIBIT 4

(Behimer Patent No. 1,883,850.)

Oct. 18, 1932.

O. BEHIMER

1,883,850

PROCESS FOR MAKING GASOLINE

Original Filed Nov. 21, 1918

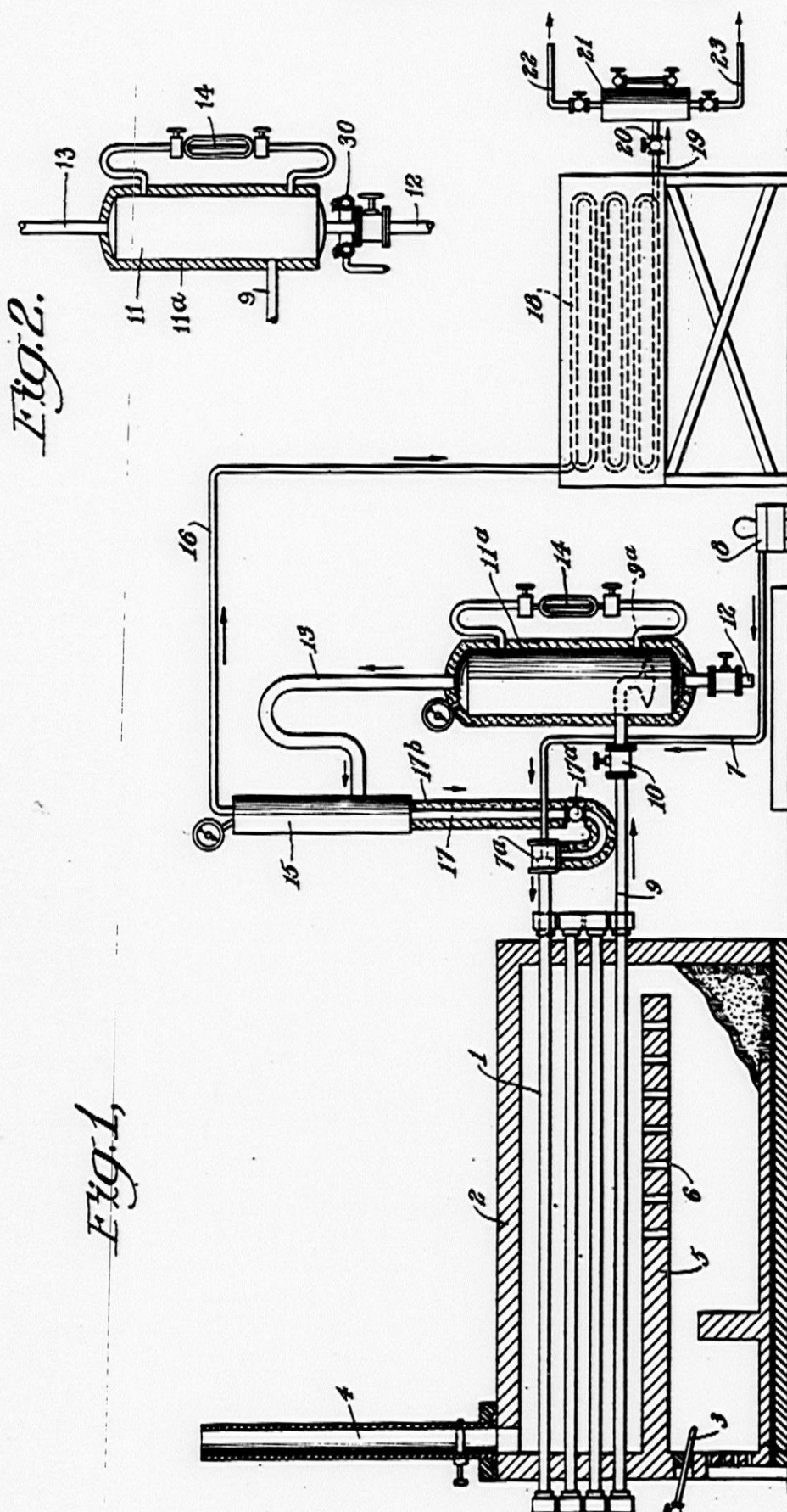


Fig. 2.

Fig. 1.

Inventor

By *Attorney* *Otto Behmer*
Carlson

UNITED STATES PATENT OFFICE

OTTO BEHMER, OF PORT ARTHUR, TEXAS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO
THE TEXAS COMPANY, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE

PROCESS FOR MAKING GASOLINE

Original application filed November 21, 1918, Serial No. 263,562, and in Canada December 3, 1921.
Divided and this application filed April 6, 1923. Serial No. 630,242.

This invention relates to methods of making condensable light oils, such as gasoline. More particularly it relates to certain novel improvements in the cracking of hydrocarbons whereby higher boiling hydrocarbons are decomposed into those of lower boiling point.

This application is a division of my co-pending application, Serial No. 263,562, filed November 21, 1918.

In prior methods of cracking hydrocarbon oils, considerable difficulty has been experienced on account of carbon formations, which occur on the sides of tubes and stills exposed to the heat required to carry on the cracking operation.

It is a broad novel feature of the herein disclosed process that substantially all of the cracking operation occurs in a vessel to which no external heat is applied, except at such times and in such quantities as are necessary to compensate for heat losses, the oil prior to its introduction to such vessel having been subjected to a high degree of cracking heat and the excess heat of the oil itself being used to effect its own decomposition. As a consequence, I avoid substantial carbon formations of the destructive character which have proved such an impediment to prior systems. The removal of the cracking operation from the heating zone also reduces the danger from fires such as frequently occur where cracking is carried on in highly heated stills and coils exposed to direct heat.

More specially my process preferably embodies a novel cyclic system in which a circuit of oil is constantly maintained under varying liquid and vapor phases. The oil to be treated on entering this circuit is subjected to a high degree of heat, but the time element is so controlled with respect thereto that there is comparatively little decomposition and deposition of carbon while it is exposed to this external heat, the oil being rapidly removed from the heating zone and conducted to the cracking zone, where without necessarily being subjected to additional heat, it undergoes a molecular decomposition whereby carbon and light products are formed and liberated. It will be understood that oil cracking or con-

version is dependent not only upon the relative conditions of pressure and temperature but also upon the time element with respect thereto, that is,—the necessary pressure and temperature must be maintained for a sufficient period of time to enable the molecular decomposition or conversion to take place. According to the present invention, this time factor is so controlled, by regulating the rate of heating the oil passing through the heating zone that the temperature thereof is progressively raised in transit and reaches the desired cracking temperature near the end of the heating coil at about the time or a little before the oil emerges therefrom. Thus, although the oil is subjected to cracking heats in the heating zone, this temperature is attained only just previous to the exit of the oil therefrom, and therefore, the oil leaves the heating coil before any substantial decomposition and incident deposition of carbon takes place. Subsequently, the highly heated oil in a state of incipient decomposition, is delivered to the cracking zone, where the desired temperature and pressure conditions are continuously sustained and the cracking of the oil and the incident decomposition of carbon are effected. The bulk of the carbon is removed from the circuit by withdrawing from the cracking zone, portions of the residual oil. Although the process, in its broad conception, is complete at this stage of the operation, the light products preferably continue the cycle, leaving the cracking zone in the form of vapor and gas. These vapors and gases are then subjected to a reduction in temperature, whereby the heavier constituents thereof, such as kerosene, are condensed. The condensate preferably is combined with the charging oil entering the heating zone, thus completing the cycle. The constituents of the desired volatility are removed from the circuit and condensed. The outlets from the circuit are so controlled that the entire system is maintained under a pressure sufficient to insure the desired molecular transformation.

My process is to be distinguished from those of the prior art, in which a circuit of liquid residuum is kept in circulation. When such oil is kept in circulation, considerable quan-

titles of carbon are formed, owing to the readiness with which this type of oil carbonizes when exposed to high temperatures, the carbon forming in fine particles in the oil, and wherever it comes in contact with heated metal surfaces, it attaches itself thereto and builds up deposits, which often cause the choking of tubes and coils. It also crystalizes the metal surfaces, thereby decreasing the tensile strength of the metal and causing the bulging and breaking of such surfaces. Any residual oil resulting from the cracking operation will necessarily contain a considerable amount of heavy polymerization products and carbon held in suspension in the oil, and to circulate such a residue through heated tubes is to continually pass into or produce in such tubes a large amount of free carbon. In my system, I do not circulate a residuum, but instead keep the residual oil removed from the application of external heat and withdraw the heavier portions thereof, which contain the bulk of the carbon, from the cycle at the cracking zone, and continue the cycle by means of the vapor generated, which contains the condensable product desired and also certain heavier vaporous constituents which are used to complete the cycle. By removing the heavier residuum from the cycle, I keep the circuit free from this source of carbon formation, and since I conduct substantially all of the cracking in a vessel to which either no external heat is applied or only a small quantity of heat is applied to maintain the requisite temperature conditions, I am thus able to effectively remove the carbon formed.

In cracking oil for gasoline, there is generally formed a considerable quantity of vapors heavier than gasoline, which may be generally designated by the term, kerosene. I preferably employ these heavier vapors as a carrier for the lighter vapors; they assist in maintaining a current of vapor by which the gasoline is removed from the cracking zone to a separator where the kerosene vapors are condensed and removed from the gasoline vapors which pass on to the condenser. The kerosene condensate, preferably at a temperature, not materially below its boiling point, is injected or otherwise suitably forced under mechanical pressure into the heavy oil charge entering and flowing through the heating tubes whereby a foamy agitated mixture is produced by the acceleration of the circulation in the heating tubes resulting from the increased volume of oil therein, thereby preventing the settling and flow of the heavier portions of the oil along the bottom of the highly heated tubes and the consequent local overheating and carbonization of the oil, thus keeping the tubes substantially free from any slight carbon formations. These kerosene constituents are an excellent mechanical conductor of heat, and there is thus produced a heat cycle which materially assists in main-

taining the proper temperatures in the heating and cracking zones. By maintaining these bodies in constant circulation, the kerosene constituents, which under existing methods have been found so difficult to decompose into lighter products, are, in my system, ultimately reduced to gasoline.

I have devised certain novel apparatus which is adapted for carrying out my process, and illustrate the preferred form thereof in the drawing in which,

Figure 1 is a diagrammatic elevation of said apparatus;

Figure 2 is a diagrammatic view of a modified cracking drum which may be substituted for that of Figure 1.

It will be understood that other apparatus besides that illustrated may be used in carrying out my process.

Referring to Fig. 1 of the illustrative drawing, a tubular heating coil 1 is located in a furnace 2, having a burner 3 and a stack 4. As shown for illustrative purposes, the coil 1 comprises a plurality of horizontally disposed rows of tubes extending through the furnace and placed the one above the other. The adjacent ends of each alternate pair of tubes in each horizontal row are conveniently connected together by horizontally positioned return bends or fittings to form horizontal coils. The several horizontal coils thus arranged are conveniently connected together at their right-hand ends by vertically disposed return bends or fittings, as shown in Fig. 1, to form a single elongated and continuous heating coil through which the oil flows and is heated to the required degree. This coil is of extended length and restricted cross-section and has a relatively large and effective heating surface whereby the stream of oil passing there-through is enabled to efficiently absorb heat and reach a high temperature with rapidity. A checkered brick baffle 5 having openings 6 may serve to distribute the heat evenly over the coil. A fresh oil charging line 7, having a jet or injector 7^a, extends to a pump 8, which is connected to a suitable source of oil supply (not shown). The pipe 9, having a valve 10, extends from the heating coil 1 to an enlarged cracking drum or chamber 11, within which it may terminate in a distributor 9^a. This distributor 9^a may be of any suitable form to thoroughly distribute and diffuse the charging oil throughout the body of oil in the drum whereby an intimate contact of the highly heated charging oil with the body of oil in the drum is effected. The cracking drum is preferably provided with a jacket 11^a of suitable insulating material to protect it against heat radiation and is equipped with a valved draw-off 12, a vapor outlet 13, and an oil gauge 14. The vapor outlet 13 extends to a separator 15, having a vapor outlet 16, and a condensate outlet

17. The vapor line 16 terminates in a water-cooled condenser coil 18, having an outlet 19 equipped with a regulatable pressure valve 20. If desired the valve 20 may be placed in the vapor line 16 but I prefer to maintain the pressure in the heating coil, cracking drum and separator through the condenser. The outlet 19 terminates in a collecting tank 21, having a valved gas outlet 22 and a valved distillate outlet 23. The condensate line 17, which is preferably insulated, as indicated at 17^b is equipped with a valve 17^a and is connected to the charging line 7 at the jet 7^a.

In conducting the process with the apparatus illustrated, the oil to be treated is forced through the charging line 7 under considerable pressure, and is rapidly flowed through the heating coil 1, where it is heated to the desired cracking temperature. Preferably this temperature is somewhat higher than the temperature at which it is desired to conduct the cracking operation and may or may not result in substantial vaporization. The oil on being forced through the coil acquires a high cracking temperature, but on account of the rapidity of its flow, decomposition is only in the incipient stages when the oil is discharged through the pipe 9 into the heat insulated cracking drum 11 where a constant body of oil is maintained at a cracking temperature under pressure. The distributor 9^a, if employed serves to discharge the oil into the cracking drum in a wide stream, thus thoroughly mixing the hot oil with the liquid body of oil maintained in the drum and diffusing the heat therethrough. This heat diffusion is materially aided by using a distributor with serrated edges. The rapid flow of the oil through the coil where it is closely confined is here suddenly retarded, as the oil enters the drum which is of ample volume. Thus the excess heat of the oil operates to maintain the body of oil at the desired cracking temperature and molecular decomposition and distillation are carried on vigorously, the higher boiling hydrocarbons continually breaking up into hydrocarbons of lower boiling point. The vapors and gas generated gather in the upper part of the cracking drum and pass out through the vapor outlet 13 to the separator 15, where there is effected a separation of hydrocarbons of desired volatility from those of less volatility. The hydrocarbons of the desired volatility pass out through the vapor line 16, by which they are conducted to the condenser 18, where they are condensed, and the condensed distillate is either intermittently or preferably continuously allowed to run into the collecting tank 21.

The temperature in the air condenser 15 is such that the less volatile hydrocarbons are condensed and dropped into the conduit 17, by which they are conducted while still hot

to the jet in the charging line or other suitable forced or applied mechanical pressure device for forcing the condensate into the charging stream. The separator is preferably somewhat elevated so as to give a considerable head of liquid in the pipe 17, which preferably contains a U bend, as illustrated, in order to form a liquid seal therein. This head of liquid, together with the high pressure at which the oil in the charging line passes the jet, this pressure being ordinarily from 50 to 100 pounds higher than the pressure in the drum, insures that the condensate shall be constantly and positively drawn into the charging line and forced under applied mechanical pressure into the coil 1. The introduction of this hot condensate into the charging line increases the volume of oil in the heating coil and thereby accelerating the flow therein and producing a foamy mixture so that local overheating is prevented and the coil is kept substantially free from any slight carbon formations. This condensate consists in a type of hydrocarbons which when decomposed does not yield any great amount of carbon so that the oil charge is constantly being diluted with oil capable of being decomposed into lighter products without the production of large amounts of carbon. This condensate reaches the jet in a heated condition, preferably at a temperature not materially below its boiling point, so as to heat the charge of oil entering the heating coil. The heat cycle formed by the kerosene constituents contributes to the maintenance of the proper temperatures in the heating coil and the cracking drum. By injecting or otherwise suitably forcing this condensate under applied mechanical pressure into the heating coil I increase the volume of oil flowing therein without increasing the total amount of oil charged into the system at any given time.

A considerable pressure is maintained throughout the system, which pressure is regulated by means of the valve 20 or the valve on the gas outlet 22. The pressure used varies with the character of the oil operated on and the character of the product desired. Ordinarily the decomposition in the cracking drum is carried on under a pressure of from 100 to 400 pounds. In utilizing oils of the type commonly employed for decomposition into products of the nature of gasoline a temperature in the drum 11 of from 700° F. to 850° with a temperature in the coil 1 of from 700° F. to 950° F. is ordinarily used. For example, in cracking a paraffin base gas oil of a Baumé gravity of about 34°, a temperature of 850° F. in the coil and of 775° F. in the drum with a pressure of approximately 200 pounds has been used to advantage.

The oil to be decomposed is constantly forced into the heating coil thereby causing a steady stream of heated oil to enter the cracking chamber. The residuum is with-

drawn preferably at such a rate that there is maintained a constant body of oil in the cracking zone.

It is desirable to equip the apparatus with the valves 10 and 17^a so that in case there is a break in the heating coil the effect of any fire resulting may be localized by closing said valves, whereby the bulk of oil in the system will be retained in the cracking drum 11. It is understood that in the normal operation of the process these valves are open.

Auxiliary heat may be supplied to the cracking drum in any suitable manner if desired, and a convenient method of providing this auxiliary heat is, as shown in Fig. 2, to insulate only the upper part of the drum and apply heat at a moderate temperature or in a relatively small quantity from any suitable heater such as is designated 30. The lower portion of this drum may be enclosed in a furnace. In the early stages of a run, since there is no danger of overheating a carbon-free surface, the drum may be heated freely until the necessary heat cycle has been generated and decomposition has begun. For this reason the arrangement of Fig. 2 possesses certain advantages over that of Fig. 1. But when decomposition begins, with a consequent deposition of carbon, the heat must be reduced, as otherwise the carbon would accumulate on the hot surfaces and build up tenacious formations thereon, thus preventing the effectual removal of the carbon and asphaltic bodies. As the run continues only a moderate heat is applied, sufficient only to offset the loss of heat due to radiation and distillation. If desired the drum may be heated by means of waste heat from the furnace 2 or in any other suitable manner.

The product obtained by the herein disclosed process is, for a cracked product, remarkably sweet, in other words, low in unsaturated compounds.

It is understood that I use the terms gasoline and kerosene in this application by way of example and that these terms are taken as types of other similar distillates which may be produced by my process. I use the term gasoline as an example of the volatile product desired which under the temperatures and pressures used is a vapor in the separator 15 and is condensable in the cooling coil 18. I use the term kerosene as an example of those constituents which under the temperatures and pressures used is a vapor in the vapor line 13 but is condensable in the separator 15. It is to be noted that the gravity and boiling point of the products which will condense in the separator 15 depends upon the temperature therein under the pressures used.

Although for illustrative purposes the invention has been shown and described in connection with apparatus of more or less spe-

cific details of construction, arrangement and location of parts, and as embodying in its mode of operation a certain series and sequence of somewhat definite steps and operating conditions, it will be understood that many of the objects and advantages of the invention may be obtained, to a greater or less extent, through the employment of apparatus of modified character or, in fact, through variations or, in some cases, omissions, of certain of the component steps, without departing from the spirit and scope of the invention.

What I claim is:

1. The continuous method of converting hydrocarbons which comprises forcing charging oil under superatmospheric pressure through a heating coil and regulating the heating therein so that it is raised to a cracking temperature, removing said oil from the coil before any material decomposition sets in and conducting it to a vessel maintained under superatmospheric pressure and not subjected to external heat where cracking is carried on by means of the heat contained in the oil, removing from the cracking zone residuum and vapors formed, separating the less volatile constituents of the latter and forcing them into the charging oil entering the heating coil.

2. The process of converting hydrocarbon oil which comprises continuously forcing oil through a heating coil at a rapid rate of flow, continuously removing said oil from the coil before material cracking takes place and introducing it into a body of oil while in its heated condition to maintain said body of oil at a temperature sufficient for decomposition without depending upon the application of other external heat thereto, removing residuum and vapors formed, separating out the heavier vapors as a condensate and continuously forcing it under maintained mechanical pressure into the heating coil, while maintaining a pressure of substantially 100 to 500 pounds throughout the system.

3. The process of converting hydrocarbon oil which comprises passing oil once through a heating coil where the oil acquires a high cracking temperature, continuously removing said oil from the coil and introducing it into a substantially constant body of oil whereby said body of oil is maintained at a somewhat lower cracking temperature and is subjected to decomposition, removing from said body of oil residual bodies and vapors formed, separating out the heavier of said vapors as a condensate and continuously forcing it free of residual oil and under maintained mechanical pressure into the heating coil, while maintaining a pressure of substantially 100 to 500 pounds throughout the system and continuously supplying charging stock to the process.

4. A process of oil conversion that comprises maintaining a body of oil under super-

atmospheric pressure at a cracking temperature in a drum by continuously supplying oil at a comparatively high cracking temperature but substantially free from decomposition into the body of oil in said drum to be cracked therein, preventing loss of heat from said drum, distilling and condensing the gasoline and kerosene fractions, separating out the kerosene fractions and returning them under maintained mechanically applied pressure and free of residual oil to the incoming supply.

5. A process of oil conversion that comprises maintaining a liquid body of oil under superatmospheric pressure at a cracking temperature in an unheated drum, insulating the drum against loss of heat and supplying unconverted oil to the drum through a highly heated coil, the rate at which the oil is heated in the coil being regulated to avoid substantial decomposition of the oil therein, withdrawing vapors from said drum, forcibly returning the heavier constituents of said vapors in liquid form and under maintained mechanical pressure to the coil, condensing the lighter constituents of said vapors under superatmospheric pressure and preventing the return of residual oil to said coil.

6. A process of oil conversion that comprises charging oil at high speed through a coil into a cracking drum, applying high temperature heat to the coil to raise the temperature of the oil so that it is delivered to the drum at a cracking temperature but without substantial decomposition, maintaining a body of liquid oil under superatmospheric pressure and at a cracking temperature in said drum to produce decomposition thereof, continuously withdrawing the vapors from the drum, separating the kerosene-like constituents from the lighter vapors, returning the kerosene-like constituents by applied mechanical pressure to the coil for passage therethrough with the charge, condensing the lighter vapors, and preventing the return of residual oil to said coil.

7. A process of oil conversion that comprises passing charging oil rapidly in a single passage through a highly heated coil and into a cracking chamber maintained under superatmospheric pressure to which no high temperature heat is applied during the cracking operation, withdrawing residue from said chamber, passing the vapors from the chamber into a separator, forcibly returning the heavier constituents of said vapors while under maintained pressure and without material drop in temperature, with the fresh charging oil into the coil, and preventing the return of residue to said coil.

8. The continuous method of cracking hydrocarbon oils which comprises charging a stream of oil into a cracking still to maintain a body of oil therein, maintaining the oil therein under superatmospheric pressure

and at a cracking temperature, removing the evolved vapors, separating out the heavier constituents thereof and cyclically returning them to the still for further treatment by positively forcing them into the stream of charging oil being supplied to the still.

9. The process of oil conversion that comprises maintaining a substantially constant body of oil in a still at a cracking temperature and superatmospheric pressure and under distillation, by continuously supplying oil thereto through a heating coil in which the oil is raised to a comparatively high cracking temperature in a single passage, separating out the heavier distillation products in the form of a hot condensate and forcing it while still hot and under maintained mechanical pressure into the coil for retreatment, preventing the return of residual oil to the coil and continuously supplying charging stock to the process.

10. A process of oil conversion that comprises passing the oil once through an extended heating zone of restricted cross-section where it is raised to a cracking temperature and thence into a cracking and distilling zone where a body of liquid oil is maintained, decomposed and distilled, separating the heavier constituents of the evolved vapors and without substantial drop of temperature or pressure, forcibly returning them to the heating zone for retreatment, removing residue from the cracking zone while preventing recirculation of residue through the heating zone, and maintaining superatmospheric pressure through the heating and cracking zones.

11. A process of oil conversion that comprises passing the oil through an extended heating zone of restricted cross-section where it is heated to a cracking temperature, delivering the heated oil into an unheated cracking and distilling zone, separating the heavier constituents of the evolved vapors and returning them without substantial drop in pressure or temperature under mechanical pressure to the heating zone for retreatment, preventing recirculation of residue through the heating zone, maintaining superatmospheric pressure through the heating and cracking zones and continuously supplying charging stock to the process.

12. A process of oil conversion that comprises passing the oil once through a heating coil where it is raised to a cracking temperature and into a drum where a substantially constant body of liquid oil is maintained and vapors evolved, separating the heavier constituents of the evolved vapors and returning them while still hot and without substantial drop in pressure under mechanical pressure to the heating coil for retreatment, removing residuum from the drum while preventing recirculation of residuum through the coil, maintaining super-

atmospheric pressure through the coil and drum and continuously supplying charging stock to the process.

13. A process of oil conversion which comprises converting the oil under cracking temperature and superatmospheric pressure, condensing the heavier constituents of the evolved vapors, mixing the condensed constituents free of residual oil and while in heated condition and under mechanical pressure with the fresh charging oil, and heating and delivering the heated mixture to the cracking zone for conversion.

14. A process of oil conversion that comprises forcing a stream of oil under superatmospheric pressure once through an elongated heating zone of restricted cross-section, applying heat to the oil in transit there-through to raise the oil to a cracking temperature, delivering the heated oil into an unheated enlarged zone where a substantially constant body of liquid oil is maintained under superatmospheric pressure and at a cracking temperature, discharging the residual oil produced in the process, removing the evolved vapors from said enlarged zone, separating out the heavier constituents thereof in the form of a hot condensate and returning said condensate while still hot and free of residual oil for retreatment by positively forcing it into the elongated heating zone against the back pressure developed therein and continuously supplying charging stock to the process.

15. The process of oil conversion that comprises maintaining a body of oil under superatmospheric pressure in a cracking chamber where a cracking temperature is maintained, by continuously forcing a stream of charging oil therein through an elongated heating coil wherein the oil is raised to a cracking temperature, the rate of heating the oil flowing through the heating coil being such as to avoid substantial deposition of carbon therein, separating out the heavier constituents of the evolved vapors and cyclically returning them for retreatment by positively forcing them under maintained mechanical pressure into the charging stream ahead of the heating coil and against the relatively high back pressure developed therein.

16. The process of oil conversion that comprises maintaining a body of oil in a chamber at a cracking temperature, continuously charging fresh oil therein at a rapid rate through an elongated charging line of restricted cross-section, maintaining superatmospheric pressure upon the oil in the chamber whereby a higher back pressure is developed in the elongated charging line by reason of the frictional resistance of the charging stream flowing therethrough, removing the evolved vapors from the cracking chamber, separating out the heavier constituents

under substantially the pressure of the chamber and cyclically returning the separated condensate to the cracking chamber for retreatment by positively forcing it into the charging stream of fresh oil at a point in the charging line remote from the chamber and against the relatively high back pressure therein.

17. A process of oil conversion that comprises forcing a stream of charging oil under superatmospheric pressure through an elongated heating coil wherein the oil is brought in a single passage to a cracking temperature, delivering the highly heated oil into a body of oil in an enlarged drum maintained under superatmospheric pressure, where the evolution of vapors takes place and carbon resulting from the cracking operation is deposited, drawing off carbon residue from said drum, separating the heavier constituents of the evolved vapors and returning them for retreatment in said coil and drum by positively forcing them into the stream of charging oil ahead of said coil.

18. A process of converting heavy into lighter hydrocarbons, which comprises passing a stream of oil through a zone where said oil is heated to a cracking temperature, passing the oil thence to an enlarged unheated zone where conversion occurs, removing the vapors, subjecting them to reflux condensation, returning reflux condensate without permitting the same to intermingle with a bulk supply of charging stock under a mechanical pressure to the heating zone for further treatment, preventing an intermingling of any residue formed in the process with the oil in the heating zone, maintaining superatmospheric pressure on the material during conversion in said heating and conversion zones and continuously supplying charging stock to the process.

19. A process of converting heavy into lighter hydrocarbons, which comprises passing a stream of oil through a coil in a heating zone where said oil is heated to a cracking temperature, transferring the highly heated oil to an enlarged unheated zone where vaporization of a substantial portion thereof occurs, passing the vapors to a dephlegmator, introducing reflux condensate from said dephlegmator without permitting said condensate to intermingle with a bulk supply of charging stock to pressure applying means to be forced under pressure through the coil in the heating zone, removing the residue formed in the process without permitting intermingling of residue with the oil in the heating coil, maintaining superatmospheric pressure on said oil undergoing conversion and continuously supplying charging stock to the process.

20. A process for converting heavy into lighter hydrocarbons, which comprises passing a stream of oil in a coil through a heating

zone where said oil is heated to a cracking temperature, transferring the highly heated oil to an enlarged unheated chamber where conversion thereof occurs, passing generated vapors to a reflux condenser, returning reflux condensate without being permitted to intermingle with a bulk supply of charging stock under a forced mechanical pressure to said heating coil, preventing a return of residual oil formed in the process to the heating coil, maintaining superatmospheric pressure on the oil undergoing conversion in said system, and continuously supplying charging stock to the process.

21. A process of converting relatively heavy into lighter hydrocarbons, which comprises passing a stream of oil through a coil in a heating zone where the oil is heated to a cracking temperature, passing the oil thence to an unheated zone where vaporization takes place, removing the vapors, subjecting them to reflux condensation, returning reflux condensate under maintained mechanical pressure to the heating zone for further cracking, removing the residue formed in the process from the system without permitting intermingling of residue with the oil in the heating zone, maintaining superatmospheric pressure on the material during treatment in said coil and chamber and continuously supplying charging stock to the process.

22. A process of converting heavy into lighter hydrocarbons, which comprises passing a stream of oil in a coil through a heating zone where the oil is heated to a cracking temperature and thence to a zone where distillation takes place, removing the vapors and passing them into a reflux condenser, returning reflux condensate free of residual oil under maintained mechanical pressure to said heating coil for further treatment therein, removing the residue formed in the process without permitting intermingling of any residue with the oil in the heating zone, and maintaining superatmospheric pressure on the oil undergoing distillation and condensation in said system and continuously supplying charging oil to the process.

23. A process of converting heavy into lighter hydrocarbons, which comprises passing a stream of oil in a coil through a zone where the oil is heated to a cracking temperature, and thence to a zone where vaporization takes place, removing the vapors and passing them into a reflux condenser, forcing both reflux condensate from said condenser under pressure and without material drop in temperature and charging stock under applied mechanical pressure in a stream through the heating coil, in removing the residue formed from the system without permitting intermingling of residue with the oil in the heating zone, in maintaining superatmospheric pressure on the oil under-

going vaporization and condensation in said system.

24. A process of converting relatively heavy into lighter hydrocarbons, which comprises passing a stream of charging oil through a coil in a heating zone where said oil is heated to a cracking temperature, passing the oil to an enlarged zone where conversion thereof occurs, introducing generated vapors to a reflux condenser, returning reflux condensate free of residual oil and mixed with charging stock under a forced mechanical pressure to said heating coil, in preventing the return of any liquid residual oil formed in the process to the heating coil, and maintaining superatmospheric pressure on the oil in said coil and said chamber.

25. A process of cracking oil, which comprises continuously passing a stream of oil through a heating coil where said oil is heated to a cracking temperature, delivering the oil to an enlarged unheated vapor chamber where vaporization takes place, removing vapors from said chamber and subjecting them to an initial condenser where portions of the vapors are condensed, subjecting the uncondensed portion of the vapors to final condensation, returning condensate from said initial condenser under applied mechanical pressure to the inlet side of said heating coil, continuously drawing off the residue formed in the process and preventing residue from returning to the heating coil and maintaining superatmospheric pressure on the oil in said heating coil, enlarged vapor chamber and initial condenser and supplying charging stock continuously to the process.

26. The process of converting hydrocarbon oil which comprises passing charging oil through a heating coil where it is raised to a cracking temperature, passing said heated oil into a body of oil in a cracking zone under superatmospheric pressure and maintained at a cracking temperature by the continual entrance therein of the stream of oil from the heating coil, removing from the cracking zone residuum and vapors formed, separating the less volatile constituents of the latter and intermingling them with the stream of charging oil entering the heating coil by forcing them therein under applied mechanical pressure, withdrawing from the circuit and condensing the lighter vapors formed, and preventing the return of residuum to the heating coil.

27. The process of converting hydrocarbon oil which comprises continuously forcing oil through a heating coil at a rapid rate of flow where it is heated to a cracking temperature, introducing it into a body of oil while in its heated condition to maintain said body of oil at a temperature sufficient for decomposition without depending upon the application of other heat thereto, removing

the vapors formed, separating out the heavier vapors as a condensate, and continuously forcing it under maintained mechanical pressure into the heating coil, while maintaining a pressure of substantially 100 to 500 pounds throughout the system.

28. The process of converting hydrocarbon oil which comprises charging oil once through a heating coil where the oil acquires a high cracking temperature, continuously removing said oil from the coil and introducing it into a cracking zone where it is maintained at a somewhat lower cracking temperature and is subjected to decomposition, separating vapors from residual oil, separating out the heavier of said vapors as a condensate, continuously forcing it under maintained mechanical pressure into the charging oil and thence through the heating coil, and preventing the return of residual oil to said heating coil while maintaining superatmospheric pressure throughout the system.

29. A process of oil conversion that comprises charging oil at high speed through a coil into an enlarged drum, applying high temperature heat to the coil to raise the temperature of the oil so that it is delivered to the drum at a cracking temperature, maintaining a body of liquid oil under superatmospheric pressure and at a high temperature in said drum to effect distillation thereof, continuously withdrawing vapors from the drum, separating the kerosene-like constituents from the lighter vapors, returning the kerosene-like constituents by maintained applied mechanical pressure to the coil for passage therethrough with the charge, condensing the lighter vapors, and preventing the return of residual oil to said coil.

30. A process of oil conversion that comprises charging oil rapidly in a single passage through a highly heated coil where the oil attains a cracking temperature, and into a cracking zone where the oil is held at a cracking temperature without material rise and cracking effected, separating the lighter constituents by vaporization from the residual oil, passing the evolved vapors through a separator, forcibly returning the heavier constituents of said vapors without material drop in pressure and under mechanical pressure with the fresh charging oil into the coil, and preventing the return of residual oil to said coil.

31. The continuous method of cracking hydro-carbon oils which comprises forcing a stream of charging oil into a body of oil in a cracking still, maintaining the oil therein under superatmospheric pressure and at a cracking temperature, discharging the residual oil from the system while preventing the return of residual oil thereto, removing the evolved vapors, separating out the heavier constituents thereof and cyclically returning

them to the still for further treatment by positively forcing them into the stream of charging oil being supplied to the still.

32. The process of oil conversion that comprises maintaining a body of oil in a chamber at a cracking temperature, continuously charging fresh oil therein at a rapid rate through an elongated charging line of restricted cross-section, maintaining superatmospheric pressure upon the oil in the chamber whereby a higher back pressure is developed in the elongated charging line by reason of the frictional resistance of the charging stream flowing therethrough, removing the evolved vapors from the cracking chamber, separating out the heavier constituents under substantially the pressure of the chamber and cyclically returning the separated condensate to the cracking chamber for retreatment by positively forcing it into the charging stream of fresh oil at a point in the charging line remote from the chamber and against the relatively high back pressure therein, and withdrawing residual oil from said chamber while preventing the return of any residual oil thereto.

33. A process of oil conversion that comprises forcing a stream of oil under superatmospheric pressure through an elongated heating coil wherein the oil is brought in a single passage to a cracking temperature, delivering the highly heated oil into a substantially constant body of oil in an unheated enlarged drum maintained under superatmospheric pressure, where the evolution of vapors takes place and carbon resulting from the cracking operation is deposited, separating the heavier constituents of the evolved vapors, returning them free of residual oil for retreatment in said coil and drum by positively forcing them under maintained mechanical pressure into said heating coil, and continuously supplying charging oil to the process.

34. A process of converting heavy into lighter hydrocarbons, which comprises passing a stream of hydrocarbon oil through a zone where said oil is heated to a cracking temperature, passing the oil thence to a zone maintained at substantially the temperature of the entering oil and where conversion occurs, separating the vapors from the residue, subjecting the vapors to reflux condensation, returning reflux condensate under maintained mechanical pressure to the heating zone for further treatment, discharging the residue formed in the process while preventing an intermingling of residue with the oil in the heating zone, maintaining superatmospheric pressure on the material during its passage through said heating and conversion zones and supplying charging oil continuously to the process.

35. A process of converting heavy into lighter hydrocarbons, which comprises pass-

ing a stream of oil through a coil in a heating zone where said oil is heated to a cracking temperature, transferring the highly heated oil into a body of oil in an unheated zone where vaporization of a substantial portion thereof occurs, passing the vapors to a dephlegmator, introducing reflux condensate from said dephlegmator, while still under pressure to pressure applying means to be forced under maintained mechanical pressure through the coil in the heating zone, removing the residue from the system without permitting intermingling of residue with the oil in the heating coil, maintaining superatmospheric pressure on said oil throughout the system and continuously supplying charging stock to the process.

36. A process of converting heavy into lighter hydrocarbons, which comprises charging a stream of oil through a heating coil where the oil is heated to a cracking temperature and thence to a zone where distillation takes place, passing the evolved vapors into a reflux condenser, returning reflux condensate under maintained mechanical pressure with said charging stream to said heating coil for further treatment therein, preventing intermingling of residual oil with the oil in the heating zone and maintaining superatmospheric pressure on the oil undergoing conversion, distillation and condensation in said system.

37. A process of converting heavy into lighter hydrocarbons, which comprises forcing a stream of charging oil through a coil in a zone where the oil is heated to a cracking temperature, and thence to an enlarged zone where vaporization takes place, removing the vapors and passing them into a reflux condenser, forcing hot reflux condensate while under maintained applied mechanical pressure into the stream of charging stock and thence through the heating coil, preventing intermingling of residual oil with the oil in the heating zone, and maintaining super-atmospheric pressure on the oil undergoing heating and vaporization in said system.

38. A process of converting relatively heavy into lighter hydrocarbons, which comprises charging a stream of oil through a coil in a heating zone where said oil is heated to a cracking temperature, passing the oil to a zone maintained at a cracking temperature where conversion thereof occurs, separating the lighter products from the residual oil by vaporization, introducing generated vapors to a reflux condenser, returning reflux condensate mixed with charging stock under a forced mechanical pressure to said heating coil, preventing the return of residual oil to the heating coil, and maintaining superatmospheric pressure on the oil undergoing conversion in said system.

39. A process of cracking oil which com-

prises subjecting oil in a fired heating zone to a cracking temperature solely by the application of external heat, delivering the highly heated oil into a heat insulated zone where separation of vapors from residual oil takes place, discharging the residual oil, subjecting separated vapors to partial condensation to separate out the heavier constituents thereof as a condensate, removing undensated vapors and positively returning condensate unmixed with residual oil by maintained mechanically applied pressure to the heating zone for further treatment and continuously supplying charging stock to the process.

40. A process of cracking oil which comprises passing oil in a stream under superatmospheric pressure through a heating coil where it is heated in transit solely by external heat to a cracking temperature, conducting the highly heated oil into an enlarged heat insulated vapor separating zone maintained under pressure and where distillation of the lighter products from the residual oil takes place, removing the vapors therefrom for condensation of the heavier constituents under superatmospheric pressure into a liquid condensate, removing the vaporized lighter constituents and compelling the positive forcible return of condensate unmixed with residual oil through the heating coil by maintained mechanically applied pressure and supplying charging stock continuously to the process.

41. A process of oil conversion which comprises heating the oil under superatmospheric pressure in a heating coil to a cracking temperature in a single passage there-through, delivering the heated oil into a cracking zone maintained under superatmospheric pressure, moderately heating the oil in said cracking zone to substantially maintain the cracking temperature and effect cracking of the oil therein, separating the cracked vapors from the residual oil and forming a condensate of the heavier constituents thereof, collecting the lighter constituents as a distillate, forcibly returning the condensate while in heated condition and under maintained mechanical pressure to the heating coil for further treatment, discharging the residual oil formed in the process, while preventing recirculation of residual oil through the heating coil, and continuously supplying charging stock to the process.

42. A process of cracking oil which comprises forcing a stream of charging oil under superatmospheric pressure through a heating coil where it is raised in single passage to a cracking temperature, delivering the heated oil into an enlarged zone where vaporization takes place under superatmospheric pressure, removing the evolved vapors and producing a condensate of the heavier constituents thereof, injecting a stream of condensate into the stream of charging oil by jet action, and pre-

venting recirculation of residual oil formed in the process to the heating coil.

43. A process of oil conversion which comprises passing oil under superatmospheric pressure through a heating coil, raising the oil in single transit through said coil to a cracking temperature but removing the oil from the heating coil in a state of incipient cracking but before substantial cracking is effected, passing the heated oil free from residue into an enlarged cracking zone where it is maintained under superatmospheric pressure and at a cracking temperature for a sufficient time to effect material cracking thereof, separating the light cracked products from the residual oil by vaporization in said enlarged zone, discharging residual oil from the system, dephlegmating the vapors under superatmospheric pressure to separate out a condensate of the heavier constituents thereof, returning the hot condensate without release of pressure thereon by maintained forced mechanical pressure to the heating coil for retreatment, without permitting intermingling of residual oil with the oil in said heating coil and continuously supplying charging stock to the process.

44. A process of oil conversion which comprises forcing a stream of charging oil rapidly and under superatmospheric pressure once through a heating coil where it is raised to a cracking temperature but without substantial cracking therein, delivering the oil to a cracking zone where superatmospheric pressure and a cracking temperature is maintained and material cracking of the oil effected, discharging the residual oil formed in the process without permitting the return of any residual oil to the heating coil, producing a condensate of the heavier constituents of the vapors evolved in said cracking zone, and cyclically returning condensate while still hot under applied mechanical pressure to the heating coil for retreatment in said coil and said cracking zone in commingled relation with the charging stream.

In witness whereof I have hereunto set my hand this 2d day of April 1923.

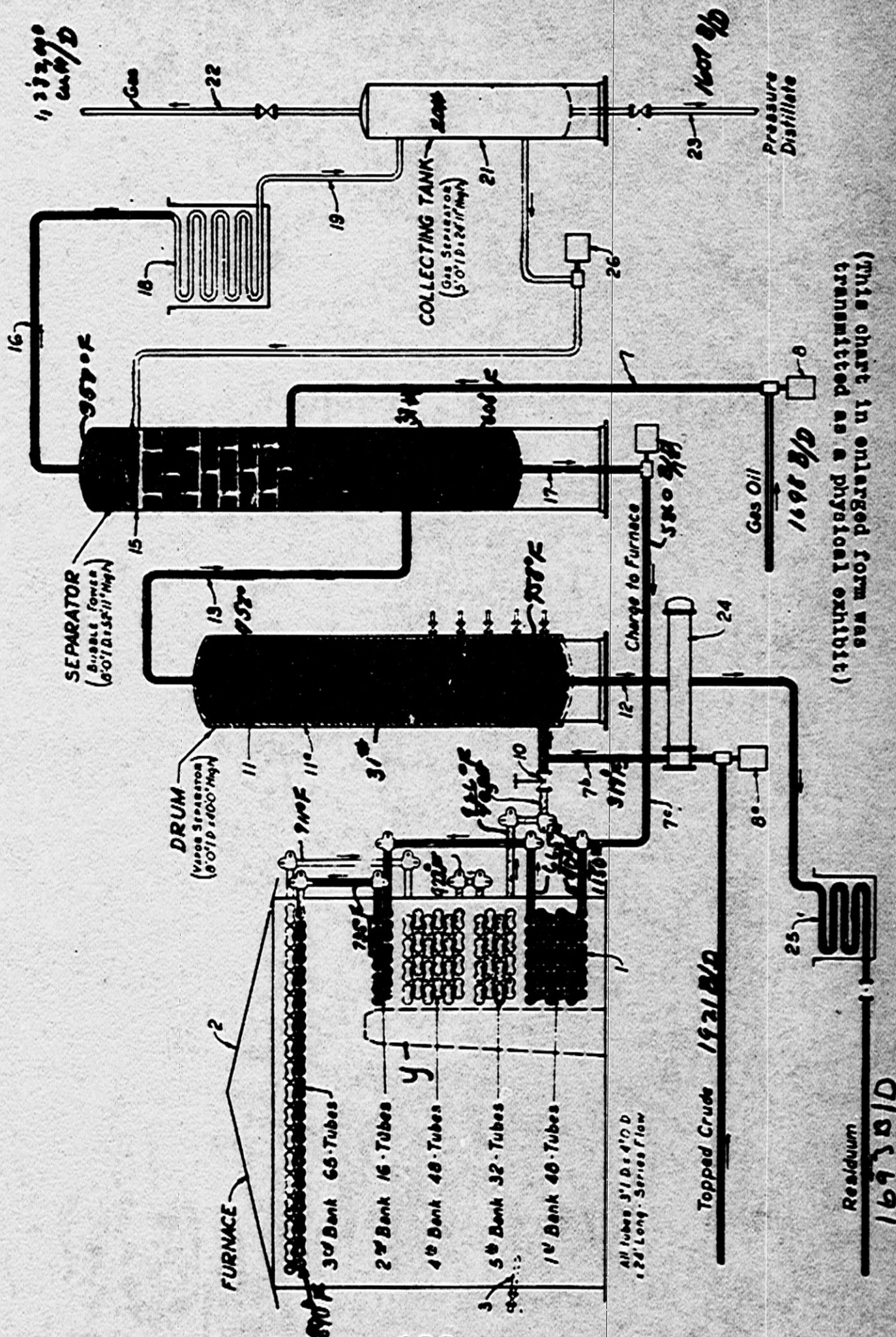
OTTO BEHMER.

IN EQUITY #1485

PLAINTIFF'S EXHIBIT # 135

FLOW DIAGRAM

DEFENDANT'S PROCESS Copy of Plaintiff's Exhibit



(this figure represents a copy of the original exhibit as was prepared by the defendant)

(Pages 829, 830, 831, 834, 835, 836 and 839 of 122
Federal Reporter 2d Series.)

TEXAS CO. v. ANDERSON-PRICHARD REFINING CORPORATION

829

**CARMICHAEL, District Director of U. S.
Immigration and Naturalization Service,
v. WONG CHOON OCK.**
No. 9685.

Circuit Court of Appeals, Ninth Circuit.

Oct. 6, 1941.

Evidence ¶571(1)

Exclusion of the son of a native born citizen of the United States based on the testimony of experts concerning son's age was improper where it appeared that experts' conclusions rested on averages of observed cases.

STEPHENS, Circuit Judge, dissenting on rehearing.

On petition for rehearing.

Petition denied.

For former opinion, see 119 F.2d 173.

Before DENMAN, MATHEWS, and STEPHENS, Circuit Judges.

PER CURIAM.

The petition for rehearing is denied.

DENMAN, Circuit Judge (concurring).

It is but fair to Director Carmichael to state that it is quite possible my refusal to give weight to the testimony of the experts is based upon my belief that their conclusions rest on averages of the observed cases. Such averages include extremes which well might cover the physical conditions of the appellee. At ten years of age, because of my size, I was excluded from footraces for boys under fourteen. It was not a soft overgrowth, for in the next year with a party of mountaineers I climbed with them to the thumb on Shasta. No doubt my bones would have shown their development to the experts. At fourteen I was tough fiberd enough to take the gaff of days of duck shooting with the market hunters in the San Joaquin delta, the pelagic sealers who wintered there.

This is written with a full appreciation of the auditors' amused tolerance of the mature, relating their early animal vigor, as recalled through the distant perspective of their childhood. However, I have no doubt that if I, at ten years of age and with a yellow skin and Mongoloid features, had then arrived from China and sought to es-

tablish under the present law my right to enter my country, as is this lad, Wong Choon Ock, and had been subjected to the same expert testimony, my citizenship wrongfully would have been denied.

STEPHENS, Circuit Judge (dissenting).

I vote for granting of the petition for rehearing because upon a more careful review of the facts I think it presents the same problems as are presented in the case of Kong Din Quong v. Haff, 9 Cir., 112 F.2d 96.



**TEXAS CO. v. ANDERSON-PRICHARD
REFINING CORPORATION.**

No. 2171.

Circuit Court of Appeals, Tenth Circuit.

Sept. 2, 1941.

Rehearing Denied Nov. 3, 1941.

1. Patents ¶167(1/4)

The specification and claims of a patent constitute a "contract" between the United States and the patentee and they should be read and construed together, not for the purpose of limiting, contracting or expanding the claims, but for the purpose of ascertaining from the entire agreement the actual intention of the parties.

See Words and Phrases, Permanent Edition, for all other definitions of "Contract".

2. Patents ¶167(1/4)

The scope of every patent is limited to the invention described in the claims read in the light of the specification.

3. Patents ¶160

Where the language of a patent is susceptible of a particular construction, the Patent Office proceedings may be resorted to, to determine whether that construction accords with the avowed intent of the parties.

4. Patents ¶246

Every element of a combination or step in a process claimed is conclusively

presumed to be material and the omission of one element, ingredient or step of a combination claim avoids infringement of that claim, regardless of whether the omitted element, ingredient or step was essential to the combination.

5. Patents ⇨229

A claim of a process patent is not infringed where any one of the steps or series of acts set forth in the claim as constituting the process is omitted, unless some equivalent step or act is substituted for the one omitted.

6. Patents ⇨328

Patent No. 1,883,850, claims 12, 14, 19, 21, 22, 23, 25, 29, 35, 36, 39 and 40 for oil cracking process *held* not infringed.

7. Patents ⇨155

A patentee who disclaims admits that he claimed more than that of which he was the original inventor and the subject matter disclaimed ceased to be a part of his invention.

8. Patents ⇨154

Where a patentee disclaims, the claims retained must differentiate in operation and result from the subject matter surrendered.

9. Patents ⇨155

In order for claims of patentee to be patentable, the claims must be inventively different from claims surrendered by the patentee, that is, the specific details or limitations in the patentee's claims, not found in the claims of the party to whom patentee surrendered, must when combined with the steps embraced in the latter, amount to "invention" over such claims.

See Words and Phrases, Permanent Edition, for all other definitions of "Invention".

10. Patents ⇨163(2)

Where applicant for patent acquiesces in rejection of claims and amends the claims, or substitutes other claims to meet the objection of the Patent Office, he will be deemed to have surrendered and disclaimed what he thus conceded and is bound by the limitations imposed and it is immaterial whether the rejection was proper.

11. Patents ⇨17(4)

Where prior to the time when hot oil pump became available in the oil cracking art, the hot reflux in patentee's process was returned to drum for further cracking, the conceiving of idea of returning it to the charging stream by means of the hot oil pump when such pump became available, so it would pass through the coil and again be raised to cracking temperature did not rise to the dignity of "invention" and was merely the exercise of mechanical skill of one trained in the art.

12. Patents ⇨328

Patent No. 1,883,850, claims 12, 14, 19, 21, 22, 23, 25, 29, 35, 36, 39 and 40, for oil cracking process, if construed as embracing clean circulation with a hot oil pump as an auxiliary to the cracking process, would be void for want of invention.

Appeal from the District Court of the United States for the Western District of Oklahoma; T. Blake Kennedy, Judge.

Action by the Texas Company against Anderson-Prichard Refining Corporation, for infringement of a patent. From a judgment dismissing the action, 32 F.Supp. 347, the plaintiff appeals.

Affirmed.

Drury W. Cooper, of New York City (Benjamin B. Schneider and Newton A. Burgess, both of New York City, Brady Cole, of Houston, Tex., and B. A. Ames, of Oklahoma City, Okl., on the brief), for appellant.

Thorley von Holst, of Chicago, Ill., Arthur C. Denison, of Cleveland, Ohio, and J. Bernhard Thiess, of Chicago, Ill. (Joseph G. Carey, of Wichita, Kan., J. H. Jarman, of Oklahoma City, Okl., and Sidney Neuman and Robert W. Poore, both of Chicago, Ill., on the brief), for appellee.

Before PHILLIPS, BRATTON, and MURRAH, Circuit Judges.

PHILLIPS, Circuit Judge.

The Texas Company brought this suit against Anderson-Prichard Refining Corporation¹ for alleged infringement of claims 12, 14, 19, 21, 22, 23, 25, 29, 35, 36, 38, 39, 40, and 41² of patent No. 1,883,-

¹ Hereinafter called the Refining Corporation.

² On the appeal, claims 38 and 41 are not pressed.

850. It was applied for November 21, 1918, and granted October 18, 1932.³ From a judgment dismissing the suit, Texas Company has appealed.

In their brief, counsel for Texas Company state that claim 39 may be regarded as typical. It reads as follows:

"39. A process of cracking oil which comprises

"(1) subjecting oil in a fired heating zone to a cracking temperature solely by the application of external heat,

"(2) delivering the highly heated oil into a heat insulated zone where separation of vapors from residual oil takes place,

"(3) discharging the residual oil,

"(4) subjecting separated vapors to partial condensation to separate out the heavier constituents thereof as a condensate,

"(5) removing uncondensed vapors,

"(6) and positively returning condensate unmixed with residual oil by maintained mechanically applied pressure to the heating zone for further treatment, and

"(7) continuously supplying charging stock to the process."

In his specification Behimer states, "This invention relates to methods of making

condensable light oils, such as gasoline"; in prior methods of cracking hydrocarbon oils, carbon forms on the sides of the tubes and stills exposed to sufficient heat to effect the cracking operation; the carbon causes choking of the tubes and coils and crystallizes the metal surfaces, thereby decreasing the tensile strength of the metal causing it to bulge and break; and in cracking oil for gasoline, there is generally formed a considerable quantity of vapors heavier than gasoline, generally called kerosene; and that under existing methods, it has been found difficult to crack kerosene into lighter products.

He further states: "It is a broad novel feature of the herein disclosed process that substantially all of the cracking operation occurs in a vessel to which no external heat is applied, except at such times and in such quantities as are necessary to compensate for heat losses, the oil prior to its introduction to such vessel having been subjected to a high degree of cracking heat and the excess heat of the oil itself being used to effect its own decomposition. As a consequence, I avoid substantial carbon formations. * * * The removal of the cracking operation from the heating zone also reduces the danger from fires. * * *"

³The original application was filed by Messrs. Holmes, Manley, and Behimer.

⁴In the specification Behimer described his process substantially as follows: It embodies a novel cyclic system in which oil is maintained under varying liquid and vapor phases. The oil on entering the circuit is subjected to a high degree of heat but the time element is so controlled that there is comparatively little cracking while the oil is exposed to external heat, the oil being rapidly removed from the heating zone to the cracking zone where, without necessarily being subjected to additional heat, it undergoes a molecular decomposition whereby carbon and like products are formed and liberated.

Cracking is dependent on relative conditions of pressure, temperature, and time. The necessary pressure and temperature must be maintained for a sufficient period of time to enable cracking to take place. The time factor is controlled by regulating the rate of heating the oil passing through the heating zone so that the temperature is raised progressively in transit and reaches the desired cracking temperature (700° to 800° F.) just previous to its exit from the heating zone. Thus, the oil leaves the

heating zone before any substantial cracking and incident deposition of carbon takes place. The highly heated oil, in a state of incipient cracking, is delivered to the cracking zone where temperature (700° to 850° F.) and pressure (100 to 400 pounds) conditions are maintained and the cracking of the oil and incident deposition of carbon are effected. "The outlets from the circuit are so controlled that the entire system is maintained under a pressure sufficient to insure the desired cracking. The bulk of the carbon is removed from the circuit by withdrawing from the cracking zone portions of the residue oil. While *"the process, in its broad conception, is complete at this stage. * * * preferably the light products" continue the cycle* leaving the cracking zone in the form of vapor and gas and are subjected to a reduction in temperature whereby the heavier constituents are condensed into kerosene. The condensate or reflux, preferably at a temperature not materially below its boiling point, is forced under mechanical pressure into the charging stream entering the heating zone, thus completing the cycle. The constituents of desired volatility are removed from the circuit and condensed. [Italics ours.]

The prior patent art⁶ had broadly taught the steps in a cracking process of returning reflux to the heating zone for further treatment and continuously withdrawing the carbon-containing residue and not returning it to the system.

The continuous coil cracking process of Rittman and de Florez operated with continuous charge and continuous withdrawal and nonreturn of residue. They did not return the hot reflux for retreatment during the operation due to the lack of a pump suitable for handling the hot materials.

A continuous once-through coil cracking process with residue withdrawn was taught in British Benton patent No. 1922.

Before Behimer entered the field, there were in commercial operation, two schools of cracking, one, the liquid phase method where a body of liquid oil was cracked and distilled generally in a tank or drum maintained under superatmospheric pressure, and the other a vapor and liquid vapor phase where the oil was heated and vaporized either completely or to a substantial degree, and cracked in a tube or coil.

Liquid phase processes were at first preferred because they operated at low temperatures and with a long time factor and made a product most closely resembling the white, sweet, natural gasoline, low in unsaturates, of simple distillation operations which was the standard product when Behimer entered the field. Vapor or liquid vapor phase processes operated at high temperatures and with a short time factor and made a product unlike natural gasoline, being rich in unsaturates and of bad color and foul odor, and difficult to treat.

In drum cracking liquid phase processes, pressure is necessary to insure the time factor and thereby insure cracking. By maintaining pressure, the boiling point of the liquid oil is materially raised. The oil is kept in the liquid state for a sufficient period of time to be cracked and vaporization does not occur until the cracking has resulted in the formation of lighter products such as gasoline and kerosene.

The unsaturates above referred to impart an antiknock quality to gasoline. With the development of the high-compression motor and the consequent demand for an antiknock gasoline, the vapor and liquid vapor phase processes came into favor.

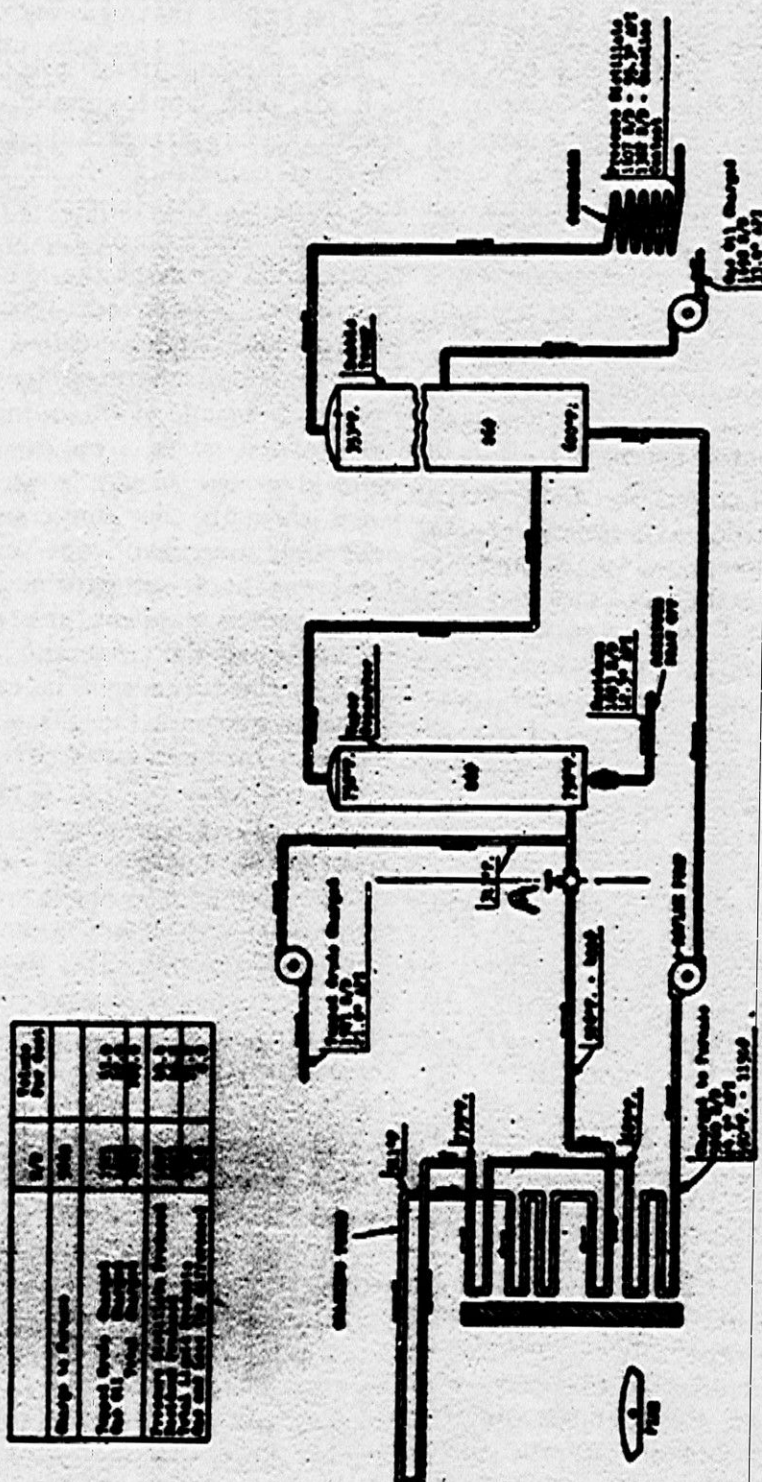
The apparatus by which the Refining Corporation's process is utilized is illustrated by the simplified drawing on the opposite page.

The cracking tubes form a continuous coil of pipe approximately one mile in length. They are arranged in five series, the first consisting of 48, the second 16, the third 65, the fourth 48, and the fifth 32 tubes. The first or upper series of tubes that extend out over the fire are called the roof bank. The several series of tubes below the roof bank are called the convection bank and are separated from the furnace fire by a bridge wall to the left thereof. The heated gases from the fire pass upward over the bridge wall, thence downward through the convection bank to a collecting tunnel and out through a stack. The roof bank extends out over the fire and receives its heat primarily by direct radiation from the fire and from the brick walls of the furnace. The convection bank is heated by convection heat from the gases and also by heat radiated from the gases and brick walls of the furnace. The roof bank and the upper series of the convection bank, being nearest the fire, receive the highest degree of heat, while the lower series of the convection bank, being farthest from the fire, receive the least amount of heat. The tubes in the roof bank are staggered so that each tube receives direct radiant heat from the fire and the brick walls.

The charging stock is forced into the lowest series of the convection bank by means of the reflux pump at a pressure of 1150 pounds per square inch and at a temperature of 590° F. The furnace temperature about this bank is 933° F. The oil travels in a direction counter to the flow of the gases in the furnace. The temperature of the oil is raised to 665° F. in this lower series. The oil then flows to the upper series of the convection bank traveling as indicated by the arrows on the drawing where the furnace temperature is 1325° F. As the oil leaves the upper series of the convection bank its temperature is raised to 735° F., a cracking temperature, but one at which cracking proceeds at a relatively slow rate. The oil then travels through the roof bank series as indicated by the arrows and when it leaves those series it has reached a tem-

⁶ Pielaticker U. S. Patent No. 477,153, British No. 1,308; Hall No. 1,175,910;

Ellis No. 1,396,090.



perature of 911° F.⁷ By the time the oil leaves the roof bank about 13 per cent of the stream has been cracked and about 15 per cent of the stream has been vaporized. The oil then passes downward through the remaining series of the convection bank and reaches a temperature of 926° F. When it passes into the outlet line, the pressure has been reduced to 400 pounds

and about 24 per cent of the stream has been cracked. By the time the oil has completed its cycle through the cracking tubes about 95 per cent of it by weight and about 99 per cent by volume has been vaporized.

The oil enters the furnace at a velocity of 10 feet per second. As it travels it expands as the result of heating and be-

⁷ After oil reaches a cracking temperature the rate of cracking doubles with

approximately each 20 degrees of increase in the temperature.

gins to vaporize. This increases the velocity so that when it leaves the roof bank it is traveling 15 feet per second. As it leaves the cracking coils it is traveling at approximately 55 feet per second. It passes through the one mile of coil in about five and one-half minutes.

Valve A is a pressure controlled valve. It is so adjusted as to maintain the pressure in the tubes at the point where the outlet tube connects with the valve at 400 pounds per square inch.

After the oil passes through valve A at a pressure of 400 pounds, the pressure decreases between the valve and the separator to 26 pounds. This release of pressure causes a substantial drop in temperature. The oil is further cooled by a stream of topped crude oil which is pumped into the transfer line between valve A and the separator. This further reduces the temperature from 926° F. at the valve to 758° F. in the bottom of the separator. Were the temperature not thus reduced, practically all the material coming from the cracking tubes by vaporization would pass out through the top of the separator. The heat exchange effects a distillation of the topped crude.

A small amount of liquid, approximately 12 barrels, is maintained in the bottom of the separator, which has a capacity of approximately 300 barrels, to seal it against vapors and prevent them from being drawn out through the residuum drawoff.

The vapor enters the separator at a velocity of 500 miles per hour due to the great expansion. This hot stream of vapor striking the topped crude at this high velocity tears it up into small particles creating a mixture of hot vapor and entrained heavy oil particles. The liquid in the bottom of the separator is churned and agitated into a froth by the stream of vapor. The vapors rise through the froth and pass upward and out of the top of the separator through the vapor line. The liquid froth is continually dropped back to the bottom of the separator and the entrained droplets or residuum tend to settle out and fall to the bottom as the vapors pass to the top of the separator. The residuum is drawn off through the line at the bottom of the vapor separator so as to maintain substantially the same amount of liquid in the separator at all times. A small amount of residuum comes from the oil that has passed through the cracking coil but the larger part comes from the topped crude. The heated vapors crack

about one per cent of the topped crude. A small amount of cracking results from any distillation process.

The vapors that pass out of the separator consist of gas, gasoline, and heavier constituents and some entrained residuum not separated out. These vapors pass into the bubble tower at a temperature of 752° F. and flow through a series of bubble decks where they are subjected to a gradual cooling. This produces condensation and a washing of the gases by the condensate which flows down the bubble decks counter to the flow of the vapors. The result is that the heavier stock is condensed and flows down to the bottom of the bubble tower where it accumulates as a clean charging stock and is picked up by the reflux or hot oil pump and charged into the cracking coil. The cracked distillate and gas pass out of the bubble tower to the condenser where the distillate is condensed and the gas remains uncondensed. From there the gas is carried to a gas separator where the gas is separated from the distillate entrained therein.

The cooling of the bubble tower is effected by introducing cold distillate at the top of the bubble tower. The exchange of heat cools the vapors and condenses the distillate and it again passes out through the top of the bubble tower.

Cold gas oil is also pumped into the bubble tower about midway between the top and bottom thereof and is heated by the vapors and tends to effect further condensation thereof. This adds to the condensed material the necessary additional clean cracking stock.

In the process, charging stock is used which is sufficiently clean to avoid carbon formation in any substantial amount in the coils. However, over a period of time, a small amount of carbon forms in the tubes, the separator, and the bubble tower. The tubes are equipped with removable plugs at the ends thereof. These plugs are removed and the carbon is loosened by an air-driven turbine cleaner having cutting edges which rotate at high speed and cut and loosen the coke. The latter is blown out by exhaust air from the turbines.

Ninety-nine per cent of the cracking takes place in the cracking coils. Cracking ceases when the oil passes through valve A due to the reduction in temperature.

Pressure is not an essential factor in cracking. Oil cracks when it is subjected to

In the vapor phase or liquid vapor phase oil cracking process, pressure is not essential to effecting either distillation or cracking. Many such processes operate at low pressure. As vapors form in the cracking coil, they cannot escape but must travel along and are cracked with the liquid. Pressure has no relation to the cracking operation itself but merely serves to economize on the length of the coil by compressing the vapors

vised a method to prevent, * * * the * * * cracking of the oil within any part of the apparatus which is externally heated. * * * They have segregated, as far as possible, the heating step and the * * * cracking step, by rapidly imparting the heat to the oil in a * * * coil subjected to high external temperatures where substantial * * * cracking was inhibited and effected substantially all of the * * * cracking in a zone * * * separate and apart from the heating zone."

In Interference 52,305, Behimer stated:

"Diametrically opposed to the efforts of others, Holmes et al. concentrated their endeavors on the cause [of carbon formation] as distinguished from the effect."

"They segregated, as far as possible, the heating step and the * * * cracking step, by imparting the heat to the oil in a zone subjected to high external temperatures where substantial * * * cracking was inhibited and effected substantially all of the * * * cracking in a zone remote from the heating zone."

In Interference 52,543, Behimer stated:

"The position of Holmes et al. [Behimer] has always been, is now and will continue to be that the processes of Holmes et al. and Dubbs are the antithesis of each other in that in the former practically all the * * * cracking takes place in the drum, while in the latter practically none takes place therein."

"The Behimer principle is a reversal of the prior art principle exemplified by Trumble.

"Instead of heating and forming carbon in the same receptacle (e.g., the coil), Behimer heats in one receptacle (the coil) and forms carbon in another (the drum)."

"The Trumble patent further indicates that the cracking is confined to the tubes by the fact that it assigns no cracking to the drum, but on the contrary assigns thereto only the function of vapor releasing which had always been the function in the drum of the prior art systems in which the cracking was done exclusively in the coil."

In Interference 49,656, Behimer stated:

"Oil boils below a cracking temperature and would go off in vapor before a cracking temperature could be attained, except for the pressure which raises its

boiling point and holds it in liquid form until cracking takes place. When cracking takes place, light oil such as gasoline and kerosene, are formed. These oils boil at a lower temperature and hence vaporize in spite of the pressure maintained. It is the vaporization of these light oils (which result from cracking) which takes place in the drum of Holmes et al."

"In the Dubbs vaporizing chamber the pressure which was maintained on the oil in the cracking tubes, where cracking takes place, is largely dropped as the oil enters the drum, thereby lowering the boiling point of all of the liquid, whether cracked or uncracked, and causing not only any gasoline and kerosene, formed by cracking in the coil, to vaporize but also the uncracked starting material to be immediately vaporized and carried over into the dephlegmator. This immediate and extensive vaporization resulting from the drop in pressure is accompanied by sufficient absorption of heat to preclude any cracking taking place in the drum."

"Holmes et al. have found it desirable * * * to effect distillation in the drum and to return the condensate, resulting from subsequent separation, to the heating coil for repassage through the system. * * * The basic principles of operation, however, are entirely independent of these auxiliary features of refinement. In the broad aspect of the invention, these features may be omitted, without altering or affecting the general mode of operation."

In the Behimer parent application he stated:

"Applicant does not contend that the counter-current flow of combustion gases and oil is new per se but does contend that the combination steps set forth in claim 82 is patentably different from the Trumble plus Ellis combination. In the particular process of applicant, the counter-current flow gives new and unexpected results in that it enables applicant to impart the final temperature to his oil near the exit of the coil. * * * As a matter of fact, instead of the counter-current flow affording an advantage to Trumble it would have the directly opposite effect because in Trumble the oil is cracked in the coil and it is, therefore, an advantage to submit the oil to the highest temperature as it enters the coil in order to bring it to a cracking temperature as rapidly as possible."

TEXAS CO. v. ANDERSON-PRICHARD REFINING CORPORATION

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32 F.Supp. 347

TEXAS CO. v. ANDERSON-PRICHARD REFINING CORPORATION.

No. 1485.

District Court, W. D. Oklahoma.

March 7, 1940.

1. Patents $\Rightarrow$ 99

Application for patent should contain written description of the device and of the manner and process of making, compounding and using it in such full, clear, concise and exact terms as to enable any person skilled in the art or science to which it pertains or to which it is most nearly connected, to make, construct, compound and use the device.

2. Patents $\Rightarrow$ 167(1/4)

The scope of every patent is limited to the invention described in the claims, read in the light of the specifications.

3. Patents $\Rightarrow$ 167(1/4)

The specifications and claims of a patent constitute a "contract" between the United States and the patentee, and they should be read and construed together, not for the purpose of limiting, contracting or expanding the claims but for the purpose of ascertaining from the entire agreement the actual intention of the parties.

See Words and Phrases, Permanent Edition, for all other definitions of "Contract".

4. Patents $\Rightarrow$ 229

Where inventor of oil cracking process devised a cyclic system for return of condensate, as part of the oil cracking process, and did not describe cyclic system as a separate and distinct step, there could be no infringement involving the cyclic system as used in connection with an entirely different process of oil cracking.

5. Patents $\Rightarrow$ 168(2)

Where proceedings in Patent Office, taken by and large, indicated that senior and junior applicants for patents on circulating systems for oil cracking compromised their dispute so that senior applicant was issued a patent involving return of condensate through "mechanically applied pressure," while junior applicant retained cyclic system in broad sense, senior applicant thus disclaimed any claim as discoverer of the cyclic system and his patent was limited to return through mechanically applied pressure.

6. Patents $\Rightarrow$ 229

Where the difficulty in oil cracking art was not that interested person would fail to think of a pump in returning condensate, but that no pump had been devised to handle oil at high temperature, a pump or other mechanically applied pressure would not be novel "invention" in itself and would not add anything to patent claims on oil cracking process, as compared with earlier patent involving a cyclic system generally, and hence could not be used to make allegedly infringing process read upon claims of the later patent.

See Words and Phrases, Permanent Edition, for all other definitions of "Invention".

7. Patents $\Rightarrow$ 328

Patent No. 1,883,850, claims 14, 19, 21, 22, 23, 25, 29, 35, 36, 38, 39, 40 and 41, for oil cracking process, held valid but not infringed.

In Equity. Action by the Texas Company against Anderson-Prichard Refining Corporation, for infringement of patent. On final submission.

Judgment for defendant.

Ames, Cochran, Monnet, Hayes & Ames, of Oklahoma City, Okl. (Newton A. Burgess, of New York City, Brady Cole, of Houston, Tex., Benjamin B. Schneider, of Chicago, Ill., and Drury W. Cooper, of New York City, of counsel), for plaintiff.

Ames, Thiess, Olsen & Mecklenburger, of Chicago, Ill., and Jarman, Brown, Looney & Watts, of Oklahoma City, Okl. (Arthur C. Denison, of Cleveland, Ohio, and J. Bernhard Thiess, Thorley von Holst, Sidney Neuman, and Robert W. Poore, all of Chicago, Ill., of counsel), for defendant.

KENNEDY, District Judge.

This is a patent case involving oil cracking process Patent No. 1,883,850 issued October 18, 1932, to Otto Behimer and assigned to the plaintiff company. The set-up of this law suit portends a battle of the giants in the petroleum refining industry. The record discloses that the principal patents involving oil cracking in the industry are concentrated in two corporations known as the Universal Oil Products Company, which is a subsidiary controlled by the Shell, the Standard of

California, and the Atlantic Refining; and the Gasoline Products Company, which is a subsidiary of the Standard of Indiana and the Texas, and that at the time of the trial agreements were in existence between many of these companies and with other large concerns engaged in the petroleum refining industry which involved indemnifying clauses, waivers, permits, cross-licensing, and the like. On the other hand, the defendant is a member of a group of refining companies comprising the Champlin, the Globe, the Skelly, the Rock Island, the Omar, the Root, and Cities Service, and perhaps some others at one time or another who are or had been users of what is known as the Winkler-Koch Process (the one challenged in this suit), and among themselves they have by assessments on the basis of barrels of gasoline manufactured, contributed to a fund through an organization known as the Winkler-Koch Patent Company for the purpose of defending this process against the charge of infringement throughout different parts of the country and in various courts. The resources of the plaintiff group tied together in the manner heretofore indicated will be recognized as very substantial, and the testimony shows that the group of which the defendant is a member has raised something in excess of \$1,000,000 for defense. The significance of the evidence which disclosed the foregoing facts in the case at bar is not fully apparent to the trial court in the solution of any of the issues of the case except perhaps to accentuate the importance of the litigation in the petroleum world, together with a basis upon which the plaintiff presents its argument, that the industry generally has recognized the legitimacy of the patent owned by plaintiff and to which tribute is paid; and the argument on behalf of the defendant that it has a right to refuse tribute to a practical monopoly in the oil cracking industry in the use of what it conceives to be a non-infringing process. So far as this court is concerned in the present action, the wealth and substantial character of the affected litigants do not greatly add to the burden of the court in seeking a solution to the problems presented, except as it may suggest an added responsibility on account of the seeming importance of the matter at hand. On the other hand, no particular worry need be occasioned the court on account of the ever-mounting expense.

Time does not seem to have been an element of importance when it is considered that the files disclose the beginning of the suit in 1933, with issues joined within reasonable time thereafter and except for a slight revamping of pleadings, the case remained dormant for nearly six years when trial was eventually reached through the "kidnapping" of a Judge from another district. It is worthy of mention that the case has been well and thoroughly tried. Five thousand pages of testimony were taken, together with the introduction of hundreds of exhibits requiring a trial period of six weeks. Over a thousand pages of printed trial briefs with appendices and proposed findings were presented, with a concluding oral argument of twenty-five hours, transcribed into a record of 750 pages. Earnest and untiring effort has been put forth to educate the trial court, little acquainted with patent litigation. The burden thereby imposed has not been a light one. To add to this complicated matter it has been developed that there are hundreds of patents covering oil cracking processes and thousands of cases in the books involving this class and kindred kinds of patents, all of which seem to have been cited on the one side or the other in counsels' briefs and arguments. One case of this character in a lifetime ought to be enough to fully satisfy the ambition of the most energetic judicial servant. With this brief outline of the picture confronting the trial court at the time a decision is imminent, an effort will be made in as brief a space as possible to outline the views of the court and at least with a reasonably prompt decision send the case on its way to the appellate courts, believing that its proper ultimate resting place should be in the bosom of the Supreme Court.

Specific reference to pleadings would seem to be unnecessary as the issues have been frankly and fully stated by counsel so as to be concise and little apt to be misunderstood. In simplified form, the issues between the litigants may be stated as follows: The plaintiff claims that the process used by the defendant is an infringement upon the claims of plaintiff's patent. The defendant claims (1) that its process is so different from the plaintiff's as not to infringe; (2) that the plaintiff abandoned or disclaimed certain features of his patent in Patent Office proceedings; and (3) that if defendant's

process is interpreted to read upon the claims of plaintiff's patent that then the patent is anticipated by prior patents and disclosures in the art. There are 44 claims set forth in the Behimer patent but not all are tendered by plaintiff as an issue in this suit. Those relied upon are claims 14, 19, 21, 22, 23, 25, 29, 35, 36, 38, 39, 40 and 41. It has seemed to be satisfactory to counsel for plaintiff to rely upon two claims as substantially setting forth the nature of the patent for the purposes of comparison with defendant's process in determining the issue of infringement. These are claims 38 and 39 and are quoted from the patent as follows:

"38. A process of converting relatively heavy into lighter hydrocarbons, which comprises charging a stream of oil through a coil in a heating zone where said oil is heated to a cracking temperature, passing the oil to a zone maintained at a cracking temperature where conversion thereof occurs, separating the lighter products from the residual oil by vaporization, introducing generated vapors to a reflux condenser, returning reflux condensate mixed with charging stock under a forced mechanical pressure to said heating coil, preventing the return of residual oil to the heating coil, and maintaining superatmospheric pressure on the oil undergoing conversion in said system.

"39. A process of cracking oil which comprises subjecting oil in a fired heating zone to a cracking temperature solely by the application of external heat, delivering the highly heated oil into a heat insulated zone where separation of vapors from residual oil takes place, discharging the residual oil, subjecting separated vapors to partial condensation to separate out the heavier constituents thereof as a condensate, removing uncondensed vapors and positively returning condensate unmixed with residual oil by maintaining mechanically applied pressure to the heating zone for further treatment and continuously supplying charging stock to the process."

Flow diagrams of both the process of plaintiff and the process of defendant have been introduced as plaintiff's Exhibits Nos. 134 and 135, respectively, with a very definite explanation and interpretation of the nature of the process used by each party. Time will not suffice to give a complete description of the theories upon which the respective counsel base their very divergent views. The matter will be

somewhat considered in attempting to discover the outstanding elements of each process with a view to solving the infringement issue.

[1-3] We learn from the interpretation of the Patent Statutes that in the application for a patent there shall be contained a written description of the device and of the manner and process of making, compounding and using it in such full, clear, concise and exact terms as to enable any person skilled in the art or science to which it pertains, or to which it is most nearly connected, to make, construct, compound and use the same. *Incandescent Lamp Patent*, 159 U.S. 465, 16 S.Ct. 75, 40 L.Ed. 221. It has been held that the scope of every patent is limited to the invention described in the claims contained in it, read in the light of the specifications. *Motion Picture Patents Co. v. Universal Film Manufacturing Co.*, 243 U.S. 502, 37 S.Ct. 416, 61 L.Ed. 871, L.R.A.1917E, 1187, Ann.Cas. 1918A, 959. Again, we see that the specifications and claims of a patent constitute a contract between the United States and the patentee and that they should be read and construed together, not for the purpose of limiting, contracting or expanding the claims but for the purpose of ascertaining from the entire agreement the actual intention of the parties. *Jensen-Salsbery Laboratories v. Franklin Serum Co.*, 10 Cir., 72 F.2d 15. These cases seem to impose upon the court the duty of examining the specifications for the purpose of clarifying as far as possible the intention of the patentee as to the nature of his device or process upon which he sought favorable action by the Government in giving him a monopoly thereon. No attempt will be made to quote fully from the specifications contained in the patent, but reference will be made to those statements which would seem to explain generally the nature of the process. It is therein stated by the applicant that in prior methods of cracking hydrocarbon oils considerable difficulty has been experienced on account of carbon formations which occur on the sides of tubes and stills exposed to the heat required to carry on the cracking operation. The applicant states that it is a broad and universal feature of his process that substantially all the cracking operation occurs in a vessel to which no external heat is applied except at such times and in such quantities as are necessary to compensate for heat losses, the oil prior to its intro-

has been said that file-wrapper history may be searched in difficult cases in avoiding the prior art to discover the precise meaning of the language which represents the contract between the applicant and the Government. *Wiegand v. Bingham Co.*, 6 Cir., 106 F.2d 546. *Certiorari denied*, 60 S.Ct. 386, 84 L.Ed. —. This seems to be the rule adopted by the Tenth Circuit. *Gasoline Products Co. v. Champlin Refining Co.*, 10 Cir., 86 F.2d 552. Reliance is had by the defendant upon many of the statements and representations made by the patentee while his patent application was being prosecuted in the Patent Office. It would be impracticable to review at length for the purposes of this memorandum the representations made by the patentee or on his behalf in the Patent Office, but suffice it to say that the applicant in construing his invention repeatedly represented it as one which was intended to prevent any decomposition in the heating coil as far as practicable and effecting substantially all the cracking in a zone separate from the heating zone which is either heat insulated or subjected only to a moderate degree of heat. This the applicant calls a distinctly new and very important invention which distinguishes it from those of the prior art. So much for the description of the patent in issue as contained in the specifications and the interpretation given in the patent proceedings in the light of which the claims heretofore referred to must be read and construed.

It is appropriate at this point to consider briefly and in simplified form the process in use by the defendant which it is alleged infringes the claims of plaintiff's patent. The process used by the defendant is not a patented process so that no opportunity is given to compare specifications or claims with those set out in plaintiff's patent. Resort must be had to the flow diagram illustrating the process used by the defendant, together with the testimony given with respect to its operation. The apparatus as disclosed by the flow diagram consists of a large number of coils located in a heating furnace where various degrees of heat are applied to the oil from incipient heating to final cracking in a series of five variously located sets of coils of small diameter and in length as shown by the testimony extending over a distance of practically a mile, through which the oil must pass before it finds its way out. The furnace is so arranged that the heat be-

comes more intense and cracking begins in the third set of tubes where the external heat is most intense, but the substantial cracking occurs in the fourth and fifth sets of coils where the external heat is less intense, but the heat of the oil itself is greater in bringing about the cracking process. All of the cracking in this apparatus is done in the coils with the exception as shown by the testimony of approximately one percent which may occur in the drum or vapor separator into which the oil is released. In its course through the coils the charge of oil reaches a vapor form in which the major portion of the cracking takes place and a pressure valve is maintained to condense into more compact form these vapors which are eventually released into the drum with only sufficient liquid therein to act as a seal and submitted to a reduced pressure of about thirty pounds. Just before the vaporized discharge from the coil reaches the vapor separator it is augmented by a quench of topped crude. The process through the vapor separator into a bubble tower then follows, with a return of the condensed product in the bubble tower to the coils. The residuum or carbon is removed from the bottom of the separator and eliminated from the circuit. A charge of gas oil through a pump is injected into the bubble tower. The manufactured product consisting of the lower boiling point constituent passes out of the top of the bubble tower into a collecting tank. This is a layman's crude description of the defendant's process, eliminating all reference to the highly technical matters concerning furnace construction, heat units, type of charge used, and the like, but it would seem sufficient to use as a matter of comparison with plaintiff's process which has been outlined heretofore. The chief distinguishing feature between the two processes appears to be, that in plaintiff's process the idea is reflected of heating in the coil without any substantial carbonization and cracking and cracking in a drum where little or no heat is applied; while in defendant's process all the cracking of the oil is performed in the coil and with little or no substantial cracking in the drum. The carbon formation in defendant's process is avoided by rushing the oil through at high speed eventually reaching vaporized form so that no substantial carbonization occurs. In plaintiff's process a liquid is maintained in the drum under high pressure for cracking purposes. In

PLAINTIFF'S EXHIBIT 8

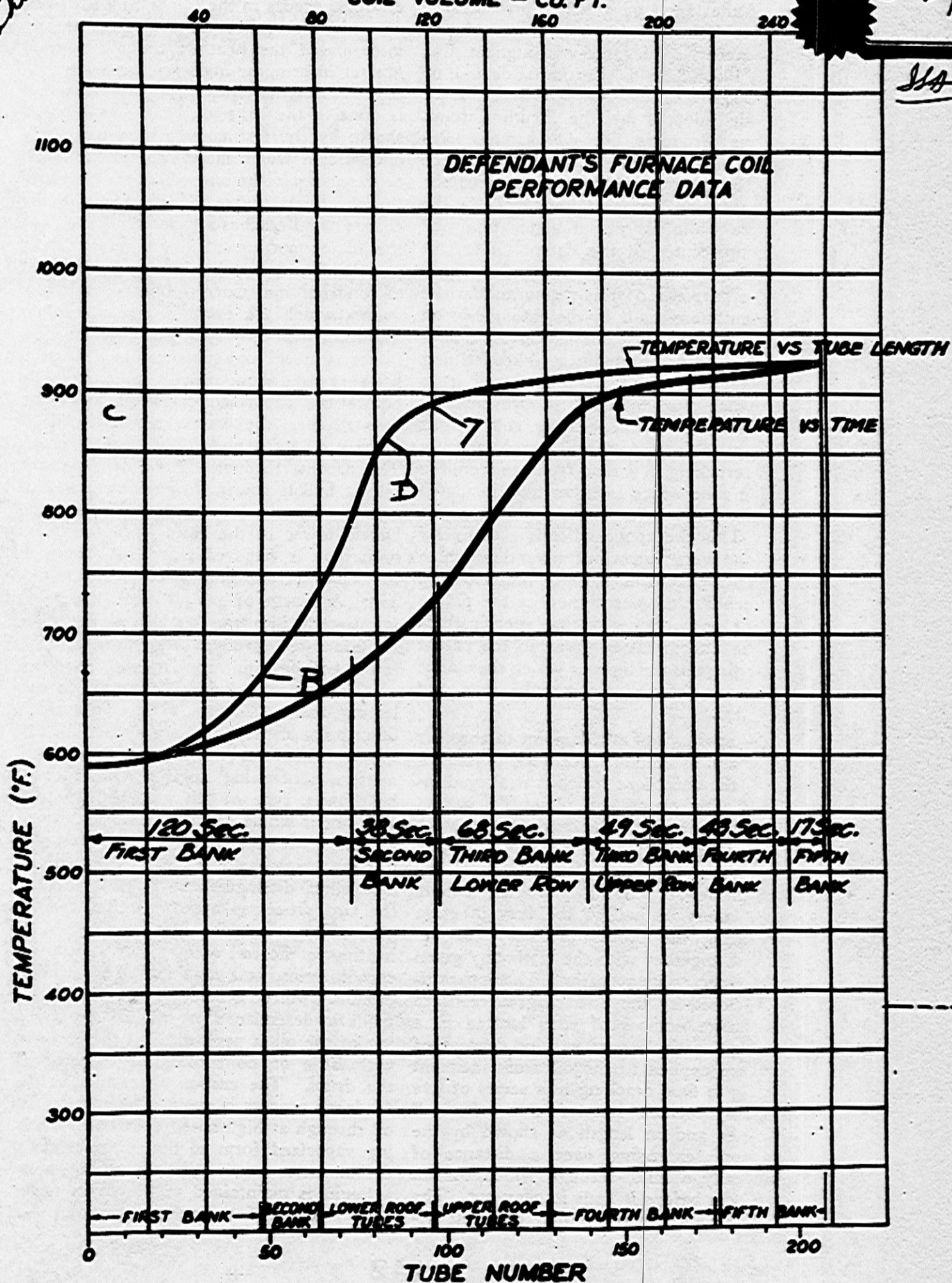
Deft. Exhibit 537

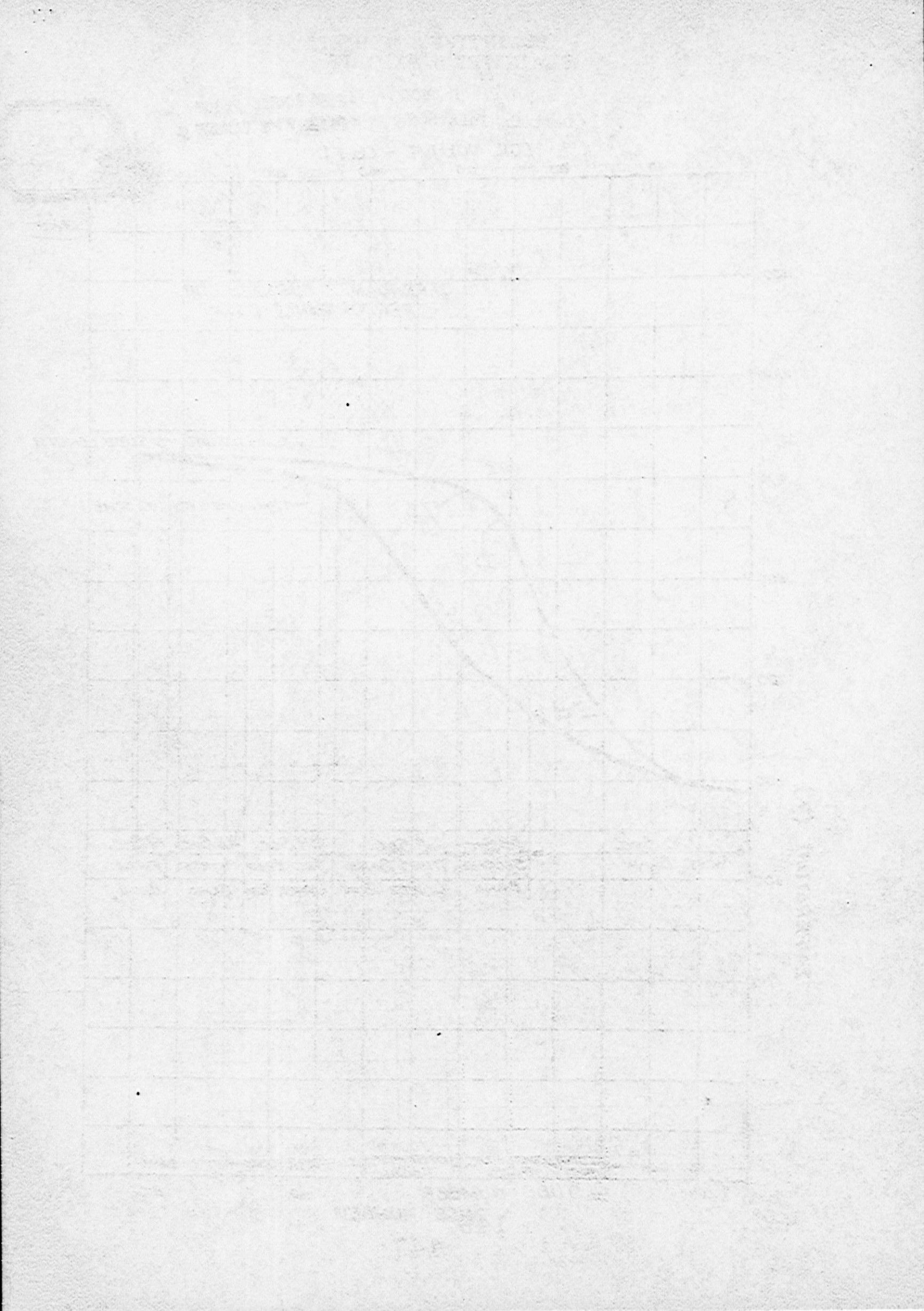
IN EQUITY #1406
PLAINTIFF'S EXHIBIT #

COIL VOLUME - CU. FT.

537

HA





PLAINTIFF'S EXHIBIT 9

(This chart in enlarged form was transmitted as a physical exhibit)

IN EQUITY #1485

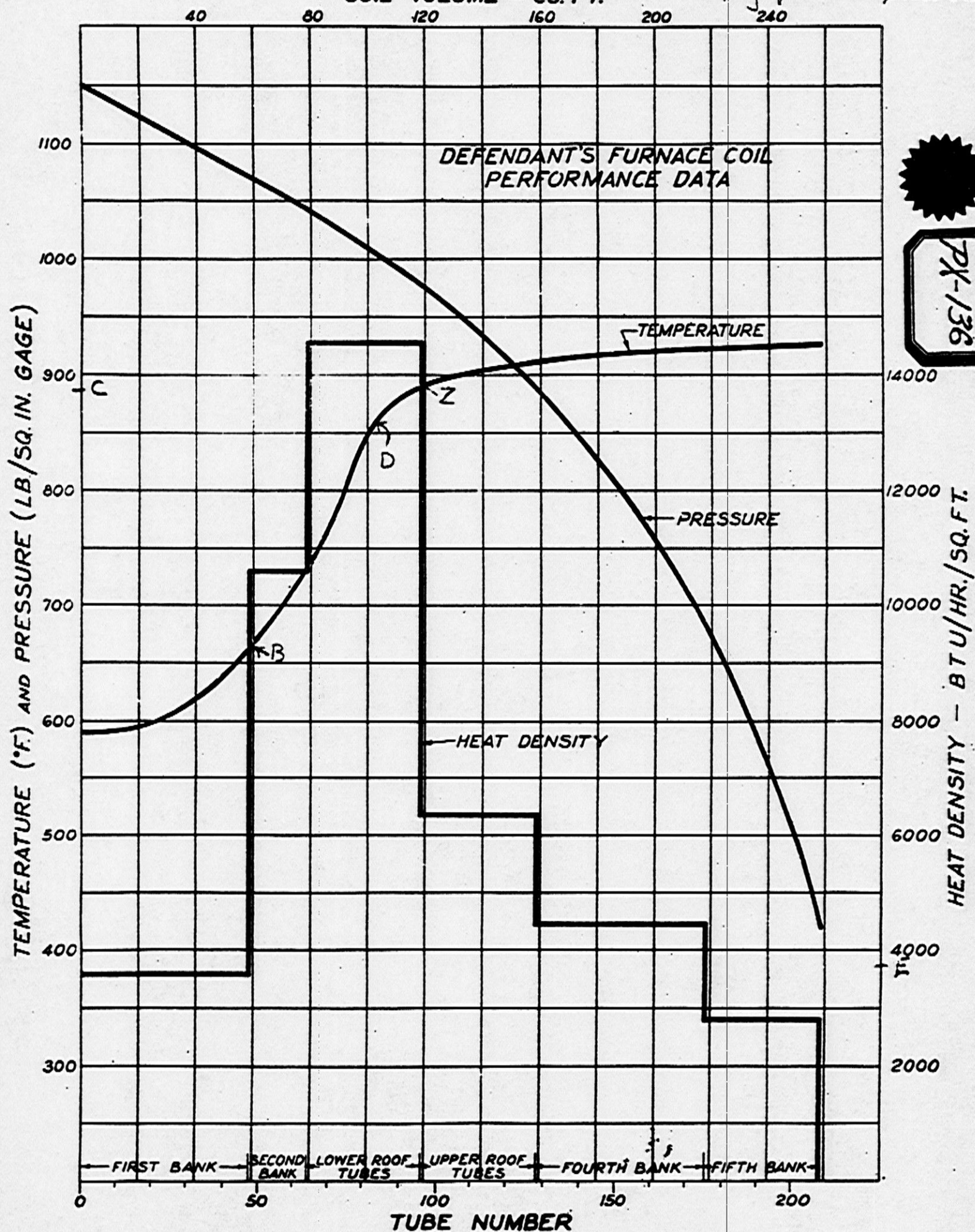
IN EQUITY #1485

PLAINTIFF'S EXHIBIT #136

PLAINTIFF'S EXHIBIT #136

COIL VOLUME - CU. FT.

Copy of Chart Exhibit



PLAINTIFF'S EXHIBIT 10

(Howard et al. Patent No. 1,869,337.)

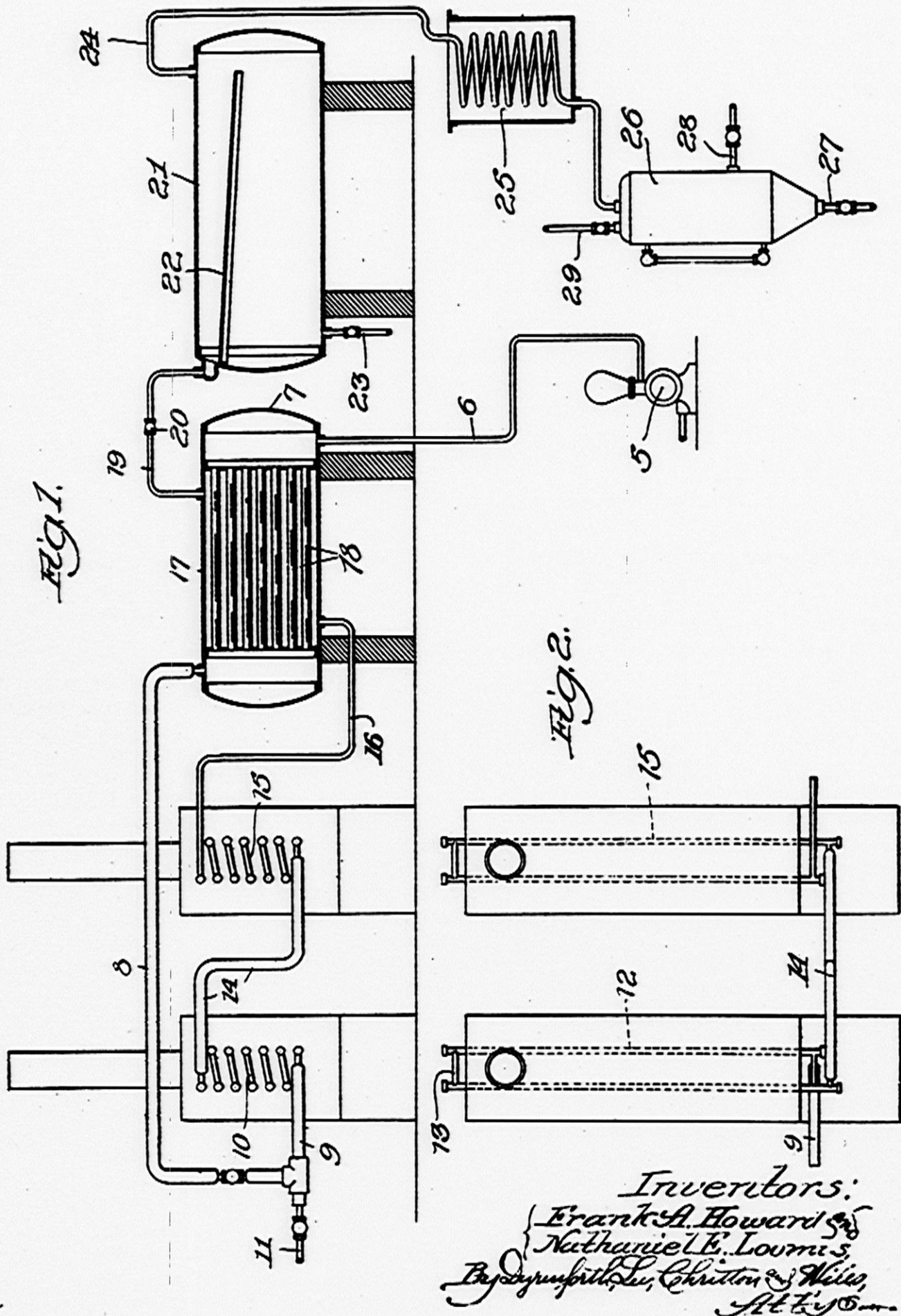
July 26, 1932.

F. A. HOWARD ET AL

1,869,337

ART OF CONVERTING OIL

Filed May 23, 1921



UNITED STATES PATENT OFFICE

FRANK A. HOWARD AND NATHANIEL E. LOOMIS, OF ELIZABETH, NEW JERSEY, ASSIGNORS, BY MESNE ASSIGNMENTS, TO GASOLINE PRODUCTS COMPANY, INC., OF NEWARK, NEW JERSEY, A CORPORATION OF DELAWARE

ART OF CONVERTING OIL

Application filed May 23, 1921, Serial No. 471,736, and in the Netherlands January 12, 1921.

The present invention relates to the art of converting hydrocarbon oils and more particularly to the reduction of the density and viscosity of heavier hydrocarbon oils and to the formation of low boiling point hydrocarbon oils therefrom. It will be clearly understood from the following description of a specific embodiment thereof, illustrated by the accompanying drawing, in which

10 Fig. 1 is a diagrammatic view, partly in elevation and partly in section, of means for carrying out the invention, and

Fig. 2 is a plan view of the preheating and converting devices.

Referring more particularly to the drawing, the numeral 5 indicates a pump, by which the oil to be treated is forced under pressure through pipe 6 into preheater 7, where it may be preheated by indirect heat exchange as more fully hereinafter described. From the preheater 7 the oil passes through pipes 8 and 9, both of which are preferably lagged, into the initial heating coil 10. Steam may be admitted into the coil through pipe 11. The initial heating coil 10 may suitably be constructed of a plurality of longitudinal capped tubes 12 connected near their ends by cross tubes 13. From the initial heating coil 10 the oil passes through pipe 14, preferably 30 lagged, to the converting coil 15, of similar construction to the coil 10. From converting coil 15 the oil passes through pipe 16 to the preheater 7, where it enters the central chamber 17 and surrounds the tubes 18 35 through which the incoming stock is passing. In passing through preheater 7 the converted oil is cooled. The cooled oil issues from preheater 7 through pipe 19, in which an expansion valve 20 is provided, whereby 40 the pressure in the oil is partially or wholly relieved. The oil then flows into drum 21 above baffle 22, and the vapors and gases are then liberated from the liquid oil, which may be removed through discharge pipe 23. The gases and vapors issuing from the drum 21 pass through pipe 24 to condenser 25, from which the condensate and the uncondensed gases and vapors pass into receiver 26. This receiver is provided with an inverted conical bottom, into which the condensed water

settles and from which it may be withdrawn through pipe 27. The oil condensate (gasoline, for example) may be withdrawn through pipe 28. The uncondensed gases and vapors may escape through pipe 29. The 55 pressure maintained upon the oil during its passage through the initial heating and converting coils is at least sufficient to maintain it substantially entirely in the liquid phase during treatment. The portion of the appa- 60 ratus wherein the oil is maintained under pressure is substantially free of spaces wherein vapor may accumulate.

The following example will illustrate the application of the present invention to the 65 conversion of a heavy hydrocarbon oil to reduce its viscosity and to produce lighter hydrocarbons therefrom. A heavy Mexican crude oil of about 12.5° Bé. gravity, 120° F. flash point and a viscosity of about 800 Say- 70 bolt 210° F. is pumped under pressure of 60 pounds gauge or higher through the preheater and the initial heating and converting coils. In the preheater 7 its temperature is raised to a point somewhat below that at 75 which cracking takes place to an appreciable extent, say about 450–500° F., at which temperature the oil enters the initial heating coil 10. A small proportion of superheated steam, for example 7 to 9 per cent. by weight of the oil, is introduced into the oil through pipe 11 as the oil enters the initial heating coil.

As the oil flows through the initial heating coil 10 the latter is fired hard in order to rapidly raise the temperature of the oil to a temperature at which conversion or cracking proceeds at a substantial rate, which temperature is above 650° F. and is preferably 725°–750° F., this temperature being acquired as the oil approaches the end of the initial heating coil. From the initial heating coil 10 the oil passes at once into the converting coil 15. This coil is fired slowly, the temperature rising only slightly to a higher cracking or conversion temperature of say 800° F. and being maintained there. During its travel through this coil the desired conversion of the oil is effected and local overheating of the coil is minimized. This coil, in the

present example, may be formed of about 800 ft. of 2-inch pipe, through which the oil travels at the rate of about 500 gallons per hour. From the converting coil 15 the oil enters the central compartment 17 of preheater 7, passing around the tubes 18 through which the incoming stock is flowing. The converted oil is cooled in the preheater to the desired temperature, say 300-325° F., at which its light hydrocarbons of the gasoline type and the steam will be in the vapor phase after reduction of the pressure on the oil. If desired or necessary, an auxiliary cooling device may be employed to aid in cooling the converted oil. The cooled oil leaving the preheater passes through expansion valve 20 in pipe 19 to the expansion drum, which may be maintained under atmospheric pressure or if desired under a slight pressure of, say, 10 pounds, to assist in the expulsion of its liquid contents.

On entering the drum 21 the light hydrocarbons formed in the conversion process and the steam are evolved as vapors, passing out through pipe 24, and the liquid products accumulate and may be withdrawn or expelled through discharge pipe 23. The temperature to which the converted oil has been cooled (300-325° F.) is such that these liquid products have a flash point of 150° F. or above. The vapors and gases issuing through pipe 24 pass through condenser 25, in which their gasoline constituents and the steam present are condensed. The condensate and uncondensed gases and vapors pass on to receptacle 26 where the water and gasoline collect and are separated while the gases and vapors pass out through pipe 29 to a suitable holder. In the example given about 10 per cent. of distillate is formed and the converted oil has a density of about 14° Bé. and a viscosity of approximately 225 at 212° F. and may be directly utilized as a fuel oil.

The temperature to which the converted oil is reduced before it enters the expansion drum may be varied in accordance with the desired characteristics of the converted oil product. Thus, if cooled to 225° F., the steam will be expelled and a liquid product of lower flash point and viscosity than above described will be produced. Or, if desired, the converted oil may be entirely cooled before pressure is released, and subsequently distilled to remove the light hydrocarbons. It is furthermore apparent that the process may be applied to other hydrocarbon oils and particularly to the heavy bottoms obtained in the ordinary reduction of such crudes as light Mexican crude, California crude or Mid-Continent crude.

It is found that by the procedure described, in which the oil is rapidly raised to a cracking temperature and subsequently its temperature slowly raised to and maintained at a high cracking temperature by slow fir-

ing, the production of coke is materially reduced or even substantially eliminated.

The preheating drum 7 may, if desired, be eliminated entirely, or another type of preheater substituted. Furthermore suitable pressure relieving devices may be inserted between the preheater and the coil or elsewhere as desired in case of plugging or stoppage in the coils, and back pressure may be guarded against by the employment of check valves at suitable points.

Although the invention has been described in connection with certain details of process and apparatus incidental to the treatment of a certain oil for a certain purpose, these are intended to be illustrative only and are not to be regarded as limitations upon the scope of the invention, except in so far as included in the accompanying claims.

We claim:

1. In the process of effecting the pyrogenetic conversion of a heavy hydrocarbon oil, continuously moving a body of said oil in succession, first through a heating zone in which the oil is raised rapidly to a temperature at which cracking takes place at a substantial rate, and thereupon, with undiminished velocity and without substantial separation of vapors through and out of a zone, in which it is heated slowly to maintain its cracking temperature while maintaining pressure on the oil sufficient to maintain it substantially in the liquid phase.
2. In the process of effecting the pyrogenetic conversion of a heavy hydrocarbon oil, first heating the said oil in a continuously flowing stream having undiminished velocity to a temperature below that at which appreciable cracking takes place, then supplying heat rapidly to the oil to bring it to an elevated cracking temperature and subsequently applying heat slowly to the oil to maintain it at an elevated cracking temperature while maintaining pressure on the oil sufficient to maintain it substantially in the liquid phase.
3. In the process of effecting the pyrogenetic conversion of heavy hydrocarbon oil, first heating the said oil in a continuously flowing stream to a temperature below that at which appreciable cracking takes place, then admixing a small proportion of steam therewith, supplying heat rapidly to the oil to bring it to an elevated cracking temperature and subsequently applying heat slowly to the oil while flowing with undiminished velocity to maintain it at an elevated cracking temperature while maintaining pressure on the oil sufficient to maintain it substantially in the liquid phase.
4. In the process of effecting the pyrogenetic conversion of a heavy hydrocarbon oil, first heating the said oil in a continuously flowing stream to a temperature below that at which appreciable cracking takes place,

then supplying heat rapidly to the oil to bring it to an elevated cracking temperature and subsequently applying heat slowly to the oil while flowing with undiminished velocity to maintain it at an elevated cracking-temperature while maintaining pressure on the oil sufficient to hold it substantially in the liquid phase and utilizing the contained heat of the treated oil to effect the preheating of fresh oil.

5. In the process of effecting the pyrogenetic conversion of a heavy hydrocarbon oil, flowing the oil in a continuous stream, first heating, the flowing oil stream to a temperature below that at which appreciable cracking takes place, then supplying heat rapidly to the flowing oil stream to bring it to an elevated cracking temperature, subsequently applying heat slowly to the flowing oil stream while flowing with undiminished velocity to maintain it at an elevated cracking temperature and maintaining pressure on the oil stream sufficient to maintain the oil substantially in the liquid state.

6. The process of effecting the pyrogenetic conversion of a heavy hydrocarbon oil which consists in continuously moving a body of oil in succession first through a heating zone in which the oil is raised rapidly to a temperature at which cracking takes place at a substantial rate, and thereupon and at substantially the same rate of speed through a zone in which it is mildly heated to maintain its cracking temperature and without substantial separation of vapors, pressure being maintained upon the oil sufficient to maintain it substantially in the liquid phase.

7. The process of effecting the pyrogenetic conversion of a heavy hydrocarbon oil into lighter hydrocarbon oils which consists in flowing the heavy oil in a restricted stream at high velocity through an initial heating zone in which it is heated rapidly to a cracking temperature above 650° F. and thereupon flowing the initially heated oil without substantial separation of vapors and at substantially the same rate of speed once only through and out of a zone, supplying heat at a slow rate therein sufficient to maintain the said temperature without more than a slight rise in temperature while maintaining a pressure of at least 60 pounds gauge on the oil in both said zones.

8. In the process of effecting the pyrogenetic conversion of a heavy hydrocarbon oil, continuously moving a body of said oil in a restricted stream at high velocity in succession, first through a heating zone in which the oil is raised rapidly to a temperature at which cracking takes place at a substantial rate, and thereupon without substantial separation of vapors and with undiminished velocity once only through and out of a zone in which it is heated slowly to maintain its cracking temperature without more than a slight rise in

temperature while maintaining a pressure of at least 60 pounds gauge on the oil in both zones.

9. The process of effecting the pyrogenetic conversion of a hydrocarbon oil into desired lower boiling products which comprises continuously forcing a stream of said oil at high velocity in succession, first through a restricted passage in a heating zone in which the oil is raised rapidly to a temperature at which cracking takes place at a substantial rate, and thereupon with undiminished velocity in a restricted stream once only through and out of a zone in which it is heated mildly without substantial separation of vapors to maintain its cracking temperature without more than a slight rise in temperature, discharging the heated oil products from the latter zone and maintaining superatmospheric pressure on the oil stream passing through said heating zones, whereby substantial conversion into desired lower boiling products is secured in said latter zone.

10. In the process of effecting the pyrogenetic conversion of a hydrocarbon oil into desired lower boiling hydrocarbon oils, continuously moving a body of said oil in a stream at high velocity in succession, first through a restricted passage in a heating zone in which the oil is raised rapidly to a temperature at which cracking takes place at a substantial rate and thereupon with undiminished velocity once only through and out of a zone in which it is heated mildly without substantial separation of vapors to maintain its cracking temperature without more than a slight rise in temperature, discharging the heated oil products from the latter zone while maintaining superatmospheric pressure on the oil in said stream passing through said heating zones whereby substantial conversion thereof into desired low boiling products in said latter heating zone is secured, and utilizing the contained heat of the treated oil to effect the preheating of fresh oil passing to said heated zones.

11. In the process of effecting the pyrogenetic conversion of a hydrocarbon oil, continuously moving a body of said oil in a restricted stream at high velocity in succession, first through a heating zone in which the oil is raised rapidly to a temperature at which cracking takes place at a substantial rate, and thereupon with undiminished velocity once only through and out of the zone in which it is heated slowly without substantial separation of vapors to maintain its cracking temperature while maintaining a pressure of at least 60 lbs. gauge on the oil in both zones, and utilizing the contained heat of the treated oil to effect the preheating of fresh oil passing to said heating zones.

12. In the process of effecting the pyrogenetic conversion of a hydrocarbon oil, forcing said oil in a restricted stream through a continuous coil in which it is subjected to a

heating means to effect rapid heating of the oil in flow through the coil to a cracking temperature, passing the oil leaving said coil at undiminished velocity once only through and out of a coil in which it is subjected to a second heating means by which mild heating of the oil passing through said coil is effected to maintain it at a cracking temperature without more than a slight rise in temperature, and maintaining superatmospheric pressure on the oil stream passing through the coils in said heating chambers.

FRANK A. HOWARD.

NATHANIEL E. LOOMIS.

PLAINTIFF'S EXHIBIT 11

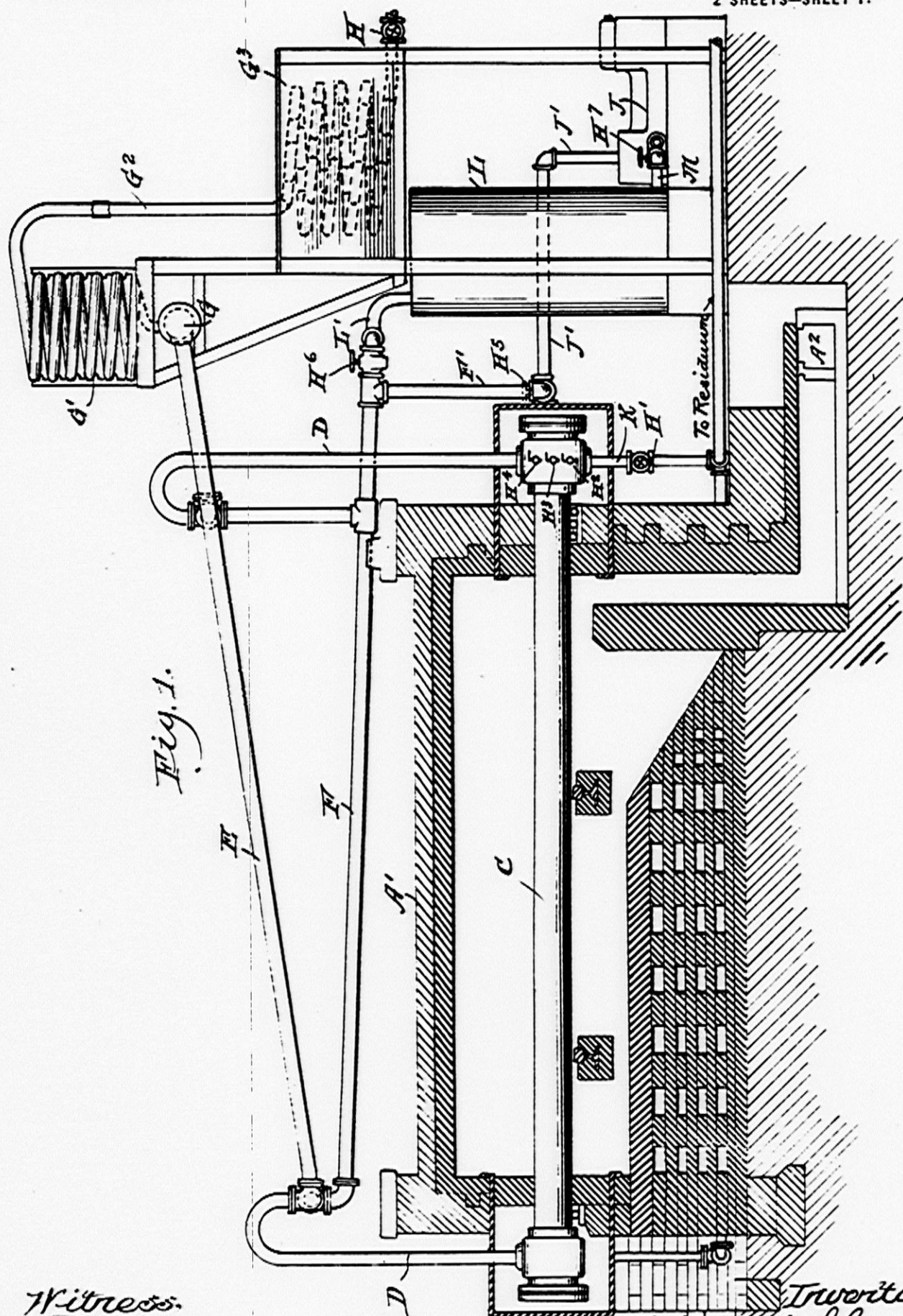
(Dubbs Patent No. 1,392,629.)

C. P. DUBBS.
PROCESS OF CONVERTING HYDROCARBONS.
APPLICATION FILED MAR. 19, 1919.

1,392,629.

Patented Oct. 4, 1921.

2 SHEETS—SHEET 1.



Witness.
J. Mann

Inventor,
C. P. Dubbs.
By Frank L. Belknap, Atty.

C. P. DUBBS.
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2 SHEETS—SHEET 2.

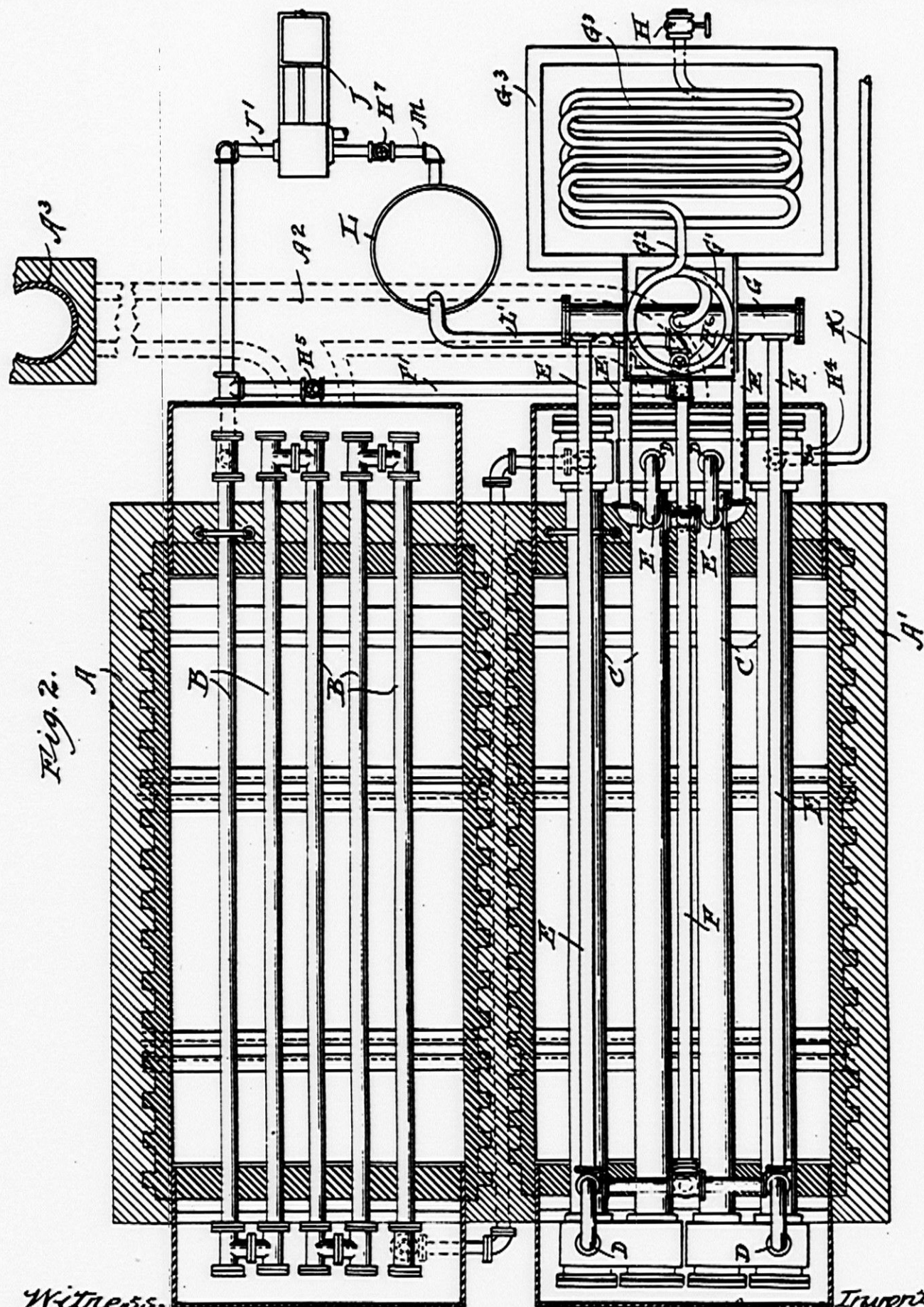


Fig. 2.

Witness,
 S. D. Mann

Inventor,
 Carbon P. Dubbs,
 By Frank R. Belknap, atty.

UNITED STATES PATENT OFFICE.

CARBON P. DUBBS, OF WILMETTE, ILLINOIS.

PROCESS OF CONVERTING HYDROCARBONS.

1,392,629.

Specification of Letters Patent.

Patented Oct. 4, 1921.

Application filed March 19, 1919. Serial No. 283,673.

To all whom it may concern:

Be it known that I, CARBON P. DUBBS, a citizen of the United States, residing in the city of Wilmette, county of Cook, and State of Illinois, have invented certain new and useful Improvements in Processes of Converting Hydrocarbons, of which the following is a specification.

This invention relates to improvements in processes of converting hydrocarbons and refers more particularly to an improved form of cracking process of the continuous type. Among the salient objects of the invention are to provide a process in which the oil is continuously fed through the cracking zone and thence through the vapor zone, and a portion of the generated vapors condensed and returned to the inlet side of the cracking zone for further treatment; to provide a process of the character above referred to in which the carbon containing residue is continuously removed from the cracking zone while the reflux condensate is returned to the cracking zone for further treatment substantially free from carbon; to provide a process which permits of the apparatus being operated for an extended period without the necessity of cleaning and in which that part of the system containing the precipitated carbon, is free from subjection to any excessive heat; to provide a process in which the reflux condensate is continuously removed from the refluxing condensing apparatus and returned to the inlet side of the system; to provide a process in which the vapors not initially condensed are finally caused to pass through a single passage for a secondary condensing action and in general to provide an improved process and also a novel apparatus of the character referred to.

The claims of the present invention are directed more particularly to the process, although it is to be understood that the apparatus itself is novel.

In the drawings:

Figure 1 is a sectional side view.

Fig. 2 is a sectional plan view.

Describing the apparatus, A and A¹ are the furnaces. A² the flue tunnel, A³ the stack.

B are the cracking tubes. C are the vaporizing tubes. D are the vapor tubes connected with the vaporizing tubes C. E are the slanting portions of the vapor tubes. F is the drainage line from the vapor tubes to

the B tubes situated in the furnace A, connected by line F¹ into line J¹ and on line F¹ is valve H⁵. G is the manifold connecting with the slanting vapor tubes E and also connecting with aerial condenser G¹ which latter connects with vapor line G² to water cooled condenser G³ and on which is valve H. J is a standard high pressure liquid pump connected with any source of supply not shown. J¹ is the discharge from said pump into coils B. K is the residuum line connected with the 10" tube and positioned in it pressure valve H¹. H², H³, H⁴ are try cocks.

Describing the operation of the process, the material to be treated is drawn from any suitable source by means of the pump J and discharge therefrom through line J¹ into and through tubes B and during the time they are passing through said tubes, they are subjected to sufficient heat to cause the desired amount of cracking. Said oil is then passed into the tubes C which are only partially filled with the oil and as the oil passes through these tubes, there is a liberation of vapors from same and which vapors pass up through the vapor tubes D, E and into header G and through aerial condenser G¹, through line G², through water condenser G³ and discharged through pressure regulating valve H. The portion of vapors condensed while passing through vapor lines E, manifold G and aerial condenser G¹ are automatically drained back through these lines into drainage line F and from there through line F¹ enter into line J¹ and back into the heating tubes B. The residue left in the coils C is drawn off through line K through pressure regulating valve H¹ to any suitable place. Pressure is maintained on the entire apparatus and is regulated by the valve H.

A light fire may be maintained under the tubes C as shown in the drawings or said tubes may be heavily insulated with cel-o-cel insulating material or any other well known insulating material to prevent loss of heat by radiation and thereby dispense with the fire under the tubes C. The level of the liquid in the tubes C is ascertained by try-cocks H², H³, H⁴ and the level controlled by valve H¹. The per cent. of vapors generated from the oil as it passes through the tubes C will depend on the amount of heat acquired by said oil while passing through the 4" coils.

I do not wish to confine myself to the above described operation except as to illustrate the principal involved and which principal may be applicable in various arranged apparatus.

For instance, the reflux distillates may be returned to the heating coils B directly or indirectly, part of them direct and part of them indirect. For instance, instead of returning the reflux condensate direct to the tubes marked B by means of line F¹, the same may be discharged into a tank marked L through line L¹ by opening the valve H⁶ which otherwise would remain closed and closing the valve H⁵ on line F¹ or part of the condensate may be returned directly back to the tubes B through line F¹ by regulating the opening of valve H⁵ and the rest discharged to tank L through line L¹ by regulating the opening of valve H⁶. Tank L may be maintained under pressure or not and it may contain the raw material that is being treated or contain wholly the reflux distillate and from this tank the contents of same are fed to the tubes B through line M into pump J and from there discharged into line J¹.

It will be noted that the reflux condensate in all cases is trapped off from the vapor lines in such manner as to prevent their returning direct to the vaporizing tubes C.

An illustrative run of the described apparatus, in accordance with my process, is as follows:

Gas oil from mid continent crude oil, such as Kansas, or Oklahoma, oils of 32 to 36 Baumé gravity is taken and continuously supplied to the pump J and thence to the 4 inch coils B which are subjected to a temperature of 750° to 860° F. The heated oil then passes to the 10 inch coils C which are maintained about half full of oil and wherein vaporization takes place. The residue is constantly drawn off through the pipe K to a suitable storage. The vapors pass up through the lines D to the pipe E into the manifold G and from thence into the aerial condenser G' where the heavier distillates are condensed and the lighter distillates pass on to the water cooled condenser G². The reflux condensation is diverted and returned to the inlet side of the tubes B, either directly through the lines F, F', or indirectly through the line F, tank L and line M to the pump. A pressure of approximately 100 lbs. to the square inch is maintained on the oil during treatment which is caused by the pressure of the generated vapors. This pressure is regulated by the valve H.

The gravity of the distillate discharge from the water cooled condenser is about 52 to 56 Baumé and in quantity is approximately somewhat more than half of the gas oil subjected to treatment.

I claim as my invention:

1. A process of converting relatively heavy into lighter hydrocarbons, consisting in passing a stream of oil through a zone where the oil is heated to a cracking temperature but without substantial vaporization, passed thence to and through a zone where vaporization takes place, removing the vapors, subjecting them to reflux condensation, returning reflux condensate for further cracking, removing the residue, after said vaporization, from the system without permitting intermingling of any substantial portion thereof with the oil in the heating zone and maintaining a pressure upon the material during distillation.

2. A process of converting heavy into lighter hydrocarbons consisting in passing in an advancing direction a stream of oil through a zone where the oil is heated to the cracking temperature but substantial vaporization prevented and thence to and through a zone where vaporization takes place, removing the vapors and condensing them, returning a portion of the condensates to the heating zone for further treatment; removing the residue after said vaporization from the system without permitting contact or intermingling of any substantial portion thereof with the oil in the heating zone and maintaining a vapor pressure upon the material under treatment during distillation and condensation.

3. A process of converting heavy into lighter hydrocarbons consisting in passing in an advancing direction a stream of oil through a heating zone where the oil is heated to the cracking temperature but substantial vaporization prevented and thence to an enlarged chamber where vaporization takes place, removing the vapors from said chamber and condensing them and returning a portion of the condensates to the heating zone for further treatment, withdrawing substantially continuously the residue from said chamber and discharging the same entirely apart from the feed of oil to the heating zone and maintaining a vapor pressure upon the material under treatment during distillation and condensation.

4. A process of converting heavy into lighter hydrocarbons consisting in passing in an advancing direction a continuous stream of oil through a heating zone where the oil is heated to the cracking temperature but substantial vaporization prevented and thence to a chamber where vaporization takes place, discharging from the chamber substantially continuously a quantity of the residue proportional to the amount of oil supplied to the heating zone and said vaporization, condensing the vapors and returning a portion of the condensates to the stream of oil for re-treatment in the heating zone and maintaining a vapor pressure upon

the material under treatment during distillation and condensation.

5. A continuous process for cracking hydrocarbons consisting in passing the same in a stream in an advancing direction from an inlet point to a discharge point separated and entirely disassociated from the inlet point, subjecting the material in the first stage of its travel to a cracking temperature while preventing substantial vaporization, affording a vaporization space above the stream during the second stage of the travel thereof to said discharge point, taking off the vapors from said vapor space and subjecting them to a condensing action, discharging into the stream at a point remote from that where vaporization occurs a portion of the condensates and maintaining a vapor pressure on the material under treatment during distillation and condensation.

6. A process of converting heavy into lighter hydrocarbons consisting in passing a stream of oil through a horizontally disposed conduit located in a heating zone, said oil substantially filling the conduit and being heated to the cracking temperature in its passage therethrough, passing the oil from said conduit into a second conduit of greater diameter than the first and horizontally disposed with its bottom in substantially the horizontal plane of the bottom of the first-named conduit whereby a vapor space is provided above the level of the oil wherein vaporization takes place, drawing off said vapors and subjecting them to a condensing action, returning a portion of the condensates to the first-named conduit, drawing off from the second conduit the residue after vaporization and maintaining upon the material under treatment during distillation and condensation a substantial pressure of the vapors generated.

7. A process of cracking oil consisting in continuously passing a stream of oil through a series of tubes seated in a cracking zone where the oil is heated to the

cracking temperature but substantial vaporization prevented, and thence to an enlarged vapor chamber where vaporization takes place, removing the vapors from said chamber, subjecting them to an initial condenser where a portion of the vapors are condensed, subjecting the uncondensed portion of the vapors to a final condensation, returning the condensate from said initial condensation to the inlet side of the cracking tubes and continuously drawing off the residue from the vapor chamber and preventing it from returning to the cracking zone and maintaining a pressure on the oil during treatment.

8. A process of cracking oil consisting in progressively passing the oil through a heating zone where the oil is heated to the cracking temperature but substantial vaporization prevented and then passing the heated oil through a vaporizing zone, forcing the carbon containing residue out of the system and preventing it from coming in contact with the incoming charging stock, taking off vapors from the vapor zone and condensing them and returning condensate therefrom to and mixing it with the fresh charging stock which is being passed through said zone.

9. The process for treating hydrocarbon oil by heating it to a cracking temperature and condensing the condensable products volatilized therefrom under pressure, consisting in raising the oil to a cracking temperature without substantial vaporization in a heating zone, passing the heated oil to a second zone where vaporization occurs, removing the vapors and subjecting them to condensation, subjecting a portion of the condensate to further cracking, taking off the carbon containing residuum from the second zone without permitting access of any substantial portion thereof to the heating zone, and maintaining a pressure upon the materials under treatment, substantially as described.

CARBON P. DUBBS.

PLAINTIFF'S EXHIBIT 12

(Donnelly Patent No. 1,712,789.)

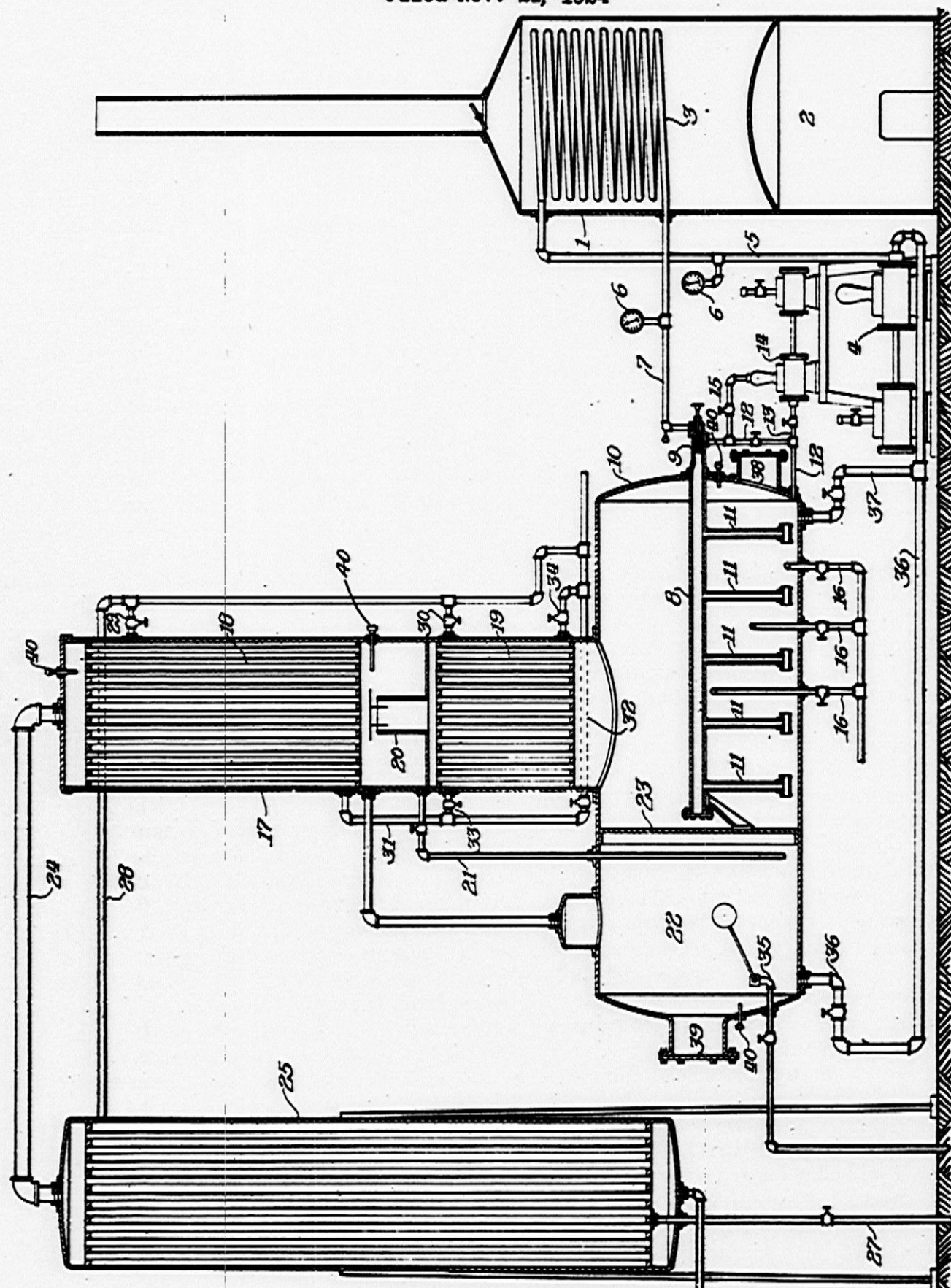
May 14, 1929.

J. F. DONNELLY

1,712,789

PROCESS FOR THE CONVERSION OF HYDROCARBON OILS

Filed Nov. 21, 1924



Witness

Ed. C. Ashman

Inventor

Joseph F. Donnelly

By Lawrence S. Daddock
Att'y

UNITED STATES PATENT OFFICE.

JOSEPH F. DONNELLY, OF LEMONT, ILLINOIS.

PROCESS FOR THE CONVERSION OF HYDROCARBON OILS.

Application filed November 21, 1924. Serial No. 751,250.

This invention relates to a process for the conversion of hydrocarbon oils. By conversion I refer to what is commonly known as cracking involving an atomic change in the molecular structure.

It is an object of my invention to effect this conversion in such a manner that the final products possess chemical characteristics more nearly approximating those of the natural hydrocarbon oils than have heretofore been produced by cracking processes.

Another object is to effect the production of the desired lighter end products without reducing the heavier products of conversion to the form of free carbon or coke.

Another object is to separate the residue from the products which it is desired to re-subject to the conversion cycle and keep the residue in liquid solution by adding thereto lighter solvent oils in such quantity as will prevent the residue from being reduced so as to prevent the formation of tar and keep the liquid residue at such a temperature as will check cracking therein in such a manner as to avoid the formation of solid end products such as free carbon and coke.

Another object is to establish such physical condition of operation that the formation of free carbon in the apparatus during its cycle of treatment is avoided.

Another object is to prevent the occurrence of total decomposition particularly in the heavier constituents which constitute marketable products, such as fuel oils, lubricating oils and waxes, which have been separated out or synthetically formed by polymerization in the zone of lower pressure.

Other objects and advantages of my invention will appear hereinafter.

In order to render my invention clear, reference is had to the accompanying drawing, in which I disclose one form of apparatus capable of carrying out my process, in which the figure is a side elevation, partly in section, of said apparatus.

In the drawing, 1 is a pipe still provided with a furnace 2 and a continuous coil 3. The liquid oil is delivered to the coil under pressure by a pump 4, through a conduit 5. Pressure gauges are shown at 6. The heated oil under pressure is delivered from the coil 3, through a conduit 7, into the outer end of an expansion chamber 8. The heated oil from the conduit 7 passes into the chamber 8 through a valve controlled nozzle 9. The chamber 8 is located within a base tank 10,

and extending outwardly from the chamber 8 to a point near the bottom of the base tank are a series of outlet conduits 11. From a low point on the base tank 10, a valve-controlled conduit 12 leads to a space within the chamber surrounding the nozzle 9 at a point to the rear of the delivery end of the said nozzle.

The oil under high velocity leaving the nozzle 9 draws up the residue oil from the tank 10 and mixes it with the stream of expanding oil or vapor issuing from the nozzle 9. To the conduit 12 is connected a valve-controlled conduit 13 which leads to a pump 14. A valve-controlled delivery pipe 15 leads from the pump 14 to the conduit 12. By closing the control-valve in the conduit 12 and opening the control valves in conduits 13 and 15, the pump 14 may be operated to draw oil from the tank 10 and deliver it to the chamber 8 through the delivery end of the conduit 12. Thus, the delivery of oil from the tank 10 to the chamber 8 may be effected by suction or forced feed by pump 14. A series of valve-controlled draw-offs from the tank 10 are shown at 16.

Mounted on the base tank 10 is a condensing column 17. The column 17 has an upper tubed section 18 and a lower tubed section 19. Between the sections 18 and 19 is a trap 20. The trap 20 collects the condensates from the upper section 18 and delivers them through a valve-controlled conduit 21 into a reflux chamber 22 formed in the tank 10 by a partition 23. A vapor outlet leads from the top of the chamber 22 to the upper end of the trap 20 as shown. A vapor outlet conduit 24 leads from the top of the column 17 to a final condenser 25. A delivery conduit 26 conducts the final condensates from the condenser 25 to a suitable run-down tank (not shown).

For the purpose of controlling the temperature of the condensers 18, 19 and 25, water is fed through a valve-controlled conduit 27 into the jacket surrounding the tubes of the condenser 25. From the condenser 25 water is led through conduit 28 and valve-controlled branch conduits 29 and 30 into the jackets surrounding the tubes of sections 18 and 19 respectively. From the lower end of the jacket of section 18, an outlet conduit 31 conducts the water to a valve-controlled discharge conduit 32. A valve-controlled branch conduit 33 connects the conduit 31 with the upper end of the jacket surrounding the tubes of section 19, and a valve-controlled outlet

conduit 34 connects the lower end of this jacket with the out-flow conduit 32. By this system of water conduits and control valves, the operating temperatures of the condenser 25 and sections 18 and 19 may be controlled at will.

By opening the valves in conduits 29, 33 and 34 and closing the valves in conduits 30 and 32, the cooling water will be caused to flow first through the jacket of section 18, thence through the jacket of section 19, and be discharged through the conduit 34 into the conduit 32. It will be apparent that the water passing through the condenser 25 and section 18 will be more or less heated when arriving at the section 19. I have therefore provided an inlet from the conduit 28 direct to the section 19, namely, the branch conduit 30. By opening the valves in conduits 30 and 34 and closing the valve in conduit 32, the cooling water may be passed direct from the condenser 25 to the section 19. It will thus be seen that by proper manipulation of the valves in conduits 29, 30, 32, 33 and 34, some or all of the cooling water from the condenser 25 may be passed through section 19 and likewise some or all of the water from section 18 may be passed through section 19.

The reflux chamber 22 is provided with a fresh oil supply conduit 35 in which is placed a float-controlled valve. By this means the fresh charging stock is fed into the chamber 22 in such a manner as to keep a constant liquid level therein.

The chamber 22 is also provided with a valve-controlled outlet conduit 36, which leads to the inlet of the pump 4. A valve-controlled conduit 37 connects the conduit 36 with the base tank 10 at a point to the right of the partition 23. Manholes are provided in the base tank 10 at 38 and 39 respectively. Thermocouples are provided at 40 to indicate the temperatures at the points shown.

In starting up, the operation is as follows: Charging stock is fed through the conduit 35 into the chamber 22, and thence through the conduit 36 to the inlet of the pump 4. The pump 4 delivers the oil to the coil 3, where it is heated by the furnace 2. From the coil 3, the oil is delivered through conduit 7 to the nozzle 9, where it is delivered into the chamber 8, and thence through the outlets 11 into the base tank 10. When the base tank is filled to the desired level, the valve in conduit 37 is opened and the surplus oil fed to the conduit 36, and back to the inlet of the pump 4. This operation is continued until the proper temperatures and pressures are reached, at which time the flow to the conduit 37 will be cut off.

In normal operation, a pressure will be maintained on the oil in coil 3 and conduits 5 and 7 by the pump 4, which will prevent ebullition thereof with consequent formation

of vapors. The degree of temperature and the amount of pressure employed in my process will vary with the nature of the oil being treated but in all cases the extraneous pressure applied by the pump 4 on the oil in the coil 3 and conduits 5 and 7 will be sufficient to prevent any normal vaporization and therefore will be in excess of the vapor tension of the oil under the cracking temperature employed. The heated oil under pressure is permitted to escape through the valve-controlled nozzle 9 at high velocity into the chamber 8, which constitutes part of and is in open communication with a zone of lower pressure. The pressure on the oil thus being suddenly released permits the heat which is stored therein to become effective to suddenly cause a transformation of the liquid oil which has been heated to or above its boiling point. at the reduced pressure, into the gaseous formation. Under ordinary circumstances, this sudden expansion of the oil by reason of its change from the liquid to the gaseous state would result in a separation of the lighter from the heavier products, and the continued cracking reaction due to the heat stored in the oil would progress into total decomposition of a portion of the hydrocarbon bodies in such a manner as to leave free carbon or coke as a part of the reaction products.

In order to control this tendency of the reaction toward total decomposition with attendant formation of free carbon or coke, I introduce at the point of expansion, a regulated quantity of cooler liquid oil. In the apparatus herein shown, I have provided two means of introducing this cooler oil. One of such means consists of the conduit 12, which conducts the cooler oil from the base tank to a point to the rear of the discharge end of the nozzle 9. The vacuum caused by the rapidly expanding oil under velocity from the nozzle 9 draws the oil through the conduit 12 and introduces it into the expanding oil within the chamber 8. The other means consists of a forced feed of cooler oil from the base tank to the same point by means of the pump 14. When the pump is operating, the valves in the conduits 13 and 15 are opened, and the valve in the conduit 12 is closed.

In the apparatus herein shown, the cooler oil which is introduced into the chamber 8 is drawn from the base tank, but it is within the scope of my invention to draw cooler oil from an outside source, in which case the oil so used may be of any nature suited to the intended purpose. If desired, I may inject water or steam into the chamber 8 to effect a regulation of the temperature therein.

I may also inject heated oil from the still 3 directly into the residue oil within the large tank 10, in which case the temperature of the residue oil will be maintained at a point which will control the vaporization and

cracking of the oil from the still in a manner to effect the desired functions.

In order that those skilled in the art may more clearly understand the peculiar characteristics of my process and therefore be aided in its application to practical use, I will now describe its relationship to the cracking reaction.

The cracking decomposition of organic compounds by heat is explained on the basis of the occurrence of intermolecular collisions of such violence that the bonds holding together the various atoms or groups are ruptured. The degree of cracking varies as the temperature to which the substance is heated varies. This explanation is supported by the well-established kinetic theory of gases. When the temperature reaches the degree to cause the necessary rate of molecular vibration, and said rate of vibration is continued, cracking will progressively continue. If the time and temperature are continued further the cracking reaction will progress into a more complete or total decomposition of a portion of the hydrocarbon constituents, resulting in the formation of free carbon which will mass together forming coke if allowed to become quiescent.

In my process the oil is heated to a cracking temperature for a sufficient length of time to effect cracking while held in liquid form by sufficient pressure for this purpose.

It is therefore an object of my process to heat the oil to the desired cracking temperature for sufficient time to cause the desired amount of cracking under an imposed pressure sufficient to prevent the vaporization thereof and subsequently to release the heated oil into a zone of lower pressure with resultant vaporization by the internally stored heat within the oil accompanied by simultaneous cracking due to its temperature which has not been reduced by expansion and vaporization below the cracking temperature thereof and to check the cracking by reducing the temperature of the heated oil in such a manner that the cracking reaction does not progress into total decomposition with the consequent formation of solid end products such as free carbon or coke.

It is also my purpose to prevent the reduction of the high boiling constituents appearing in the zone of lower pressure to the form of solid end products such as free carbon or coke. Such solid end products would ordinarily appear upon the total decomposition of portions of such high boiling constituents due to the temperature thereof combined with the length of time said constituents would normally be subjected to said temperature in said zone of lower pressure. It is therefore an object of my process to prevent the reduction of such higher boiling oils to a condition wherein solid end products such as coke or free carbon are formed by reducing

the temperature thereof in such a manner that total decomposition is avoided.

In my preferred form herein disclosed I effect this temperature control by the introduction of condensates into the mass of oil in the base of the tower which not only maintains the proper temperature of the oil in said base to prevent the formation of solid end products due to total decomposition, but also adds oils of a character which keep the residue in a liquid condition. These condensates thus introduced are continuously revaporized thus extracting heat from said higher boiling oils. The vapors thus formed are continuously removed from said higher boiling oils, condensed and returned into said higher boiling oils in the base of the tower.

The products from the chamber 8 are fed into a body of oil in the base tank 10 through the conduits 11 and undergo a heat interchange therewith, resulting in the vaporization of those constituents that are vaporizable at the temperature at which the oil in the base tank is maintained.

In order to return the condensates to the base tank 10 for the purposes described, I have provided the condenser section 19 and cooling apparatus as heretofore described.

By suitable regulation of the supply of cooling water to the jacket of the section 19, I am enabled to return to the base tank the necessary amount of condensates at the proper temperature for the purposes set forth. The condensates from section 18 are collected in the trap 20 and are passed to the chamber 22. Any vapors which are formed in the chamber 22 pass to the condensing section 18 and final condenser 25. The liquid in chamber 22 is heated by a heat interchange with the liquid on the other side of the partition 23, and this heating will effect a dehydration of the oil in chamber 22, which is composed of fresh charging stock and condensates from the condenser 18. The liquid from chamber 22 is recycled by sending the same through conduit 36 to the pump 4. The recycled oil is composed of a mixture of dehydrated fresh oil and selected condensates unmixed with the residue oil.

By means of the pressure and temperature indicating devices and qualitative tests of the products, the operator may readily guide the process so as to produce the desired results.

The control of the cracking reaction in the coil 3 pipe 7, chamber 8 and base tank 10 may be readily accomplished by the operator. It is well known to those skilled in the art that as soon as a cracking reaction progresses into total decomposition gases will be evolved. It is also well known to those skilled in the art that even though the cracking temperatures are above the range of the critical temperatures of many of the lighter hydrocarbons, nevertheless the vapor pres-

sure of these substances is very much lowered by the fact that they are in solution in a fairly large body of heavy hydrocarbon oil. With sufficient pressure, therefore, it is possible to maintain in a liquid phase in decomposing heavy oils even though the temperatures employed are above the critical temperatures of some of the hydrocarbons produced by decomposition. I have also determined that the cracking reaction can be carried on for a much longer period before total decomposition sets in if vaporization is prevented by superimposed pressure. I have observed in practical operation that as long as the oil in the coil 3 remains in liquid phase the strokes of the pump 4 are positively indicated by a corresponding oscillating deflection of the indicating needles of the pressure gauges 6. If through improper operating conditions gases or vapors should accidentally be formed in the coil 3 their presence will be immediately reflected by a strong advance of the pressure indicating needles of the gauges 6 and with accompanying cessation of the oscillation thereof. The accidental occurrence of gases or vapors in the coil may be immediately remedied by a decrease of fire box temperatures but is preferably accomplished by an opening of the valve controlling the expansion nozzle 9 and speeding up the strokes of the pump 4 which causes a greater volume of oil to pass through the coil 3 which reduces the time of exposure of the oil to the heat. By maintaining a liquid phase reaction in the coil 3 I am enabled to effect a commercial amount of cracking therein before it becomes necessary to further control the cracking reaction by temperature reduction to prevent it from proceeding into a condition where total decomposition of a portion of the oil is effected with consequent formation of free carbon.

In applying tests in order to guide my process so that free carbon will not be formed in the cracking reaction, I proceed as follows. The oil is heated under a gradually increasing temperature and under an extraneous applied pressure in excess of the vapor tension of the oil being treated until the oil leaving the conduit 7 reaches a temperature of 700 to 800 degrees F. at which temperature samples of the oil are withdrawn from the conduit 7 and tested for free carbon. The temperature is then gradually increased on the oil being treated until the free carbon test shows traces of free carbon. Then the flow is increased on the oil stream thus reducing the temperature of the oil being treated until no trace of free carbon is found by the applied test. I also test samples of oil drawn from the base tank 10. If the test shows traces of free carbon I increase the speed of the cooling of the heated oil in the zone of lower pressure by reducing the temperature of the condenser section 19, thereby deliver-

ing cooler condensates in a greater quantity into the base tank 10 until the free carbon test of the oil therein shows that the desired result of checking the cracking reaction before the formation of free carbon has been accomplished. The free carbon test of the oil in the base tank 10 will indicate whether free carbon is being formed in any part of the cracking reaction, since, if such is the case, free carbon will ultimately appear in and be detected by the free carbon test of samples taken from the base tank 10.

It will thus be seen that I have provided a process in which the cracking reaction is conducted in such a manner that total decomposition with its attendant formation of free carbon or coke is avoided in the successive steps thereof in an efficient and easily controlled manner.

Having described my invention, what I claim is:

1. A process for the conversion of hydrocarbon oils, which consists in heating a mass of relatively heavy hydrocarbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil before the cracking reaction reaches the condition where free carbon would be formed therein into a zone of lower pressure, and checking the cracking reaction in said zone of lower pressure before it reaches the condition where free carbon would be formed therein, in such a degree as to prevent the formation of free carbon in said zone by the simultaneous regulated introduction of a cooler hydrocarbon oil into said zone.

2. A process for the conversion of hydrocarbon oils, which consists in heating a mass of relatively heavy hydrocarbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil before the cracking reaction reaches the condition where free carbon would be formed therein, into a zone of lower pressure containing a separate mass of cooler hydrocarbon oil, and checking the cracking reaction in said zone of lower pressure before it reaches the condition where free carbon would be formed therein, in such a degree as to prevent the formation of free carbon in said zone by the simultaneous regulated introduction of a cooling agent into said zone.

3. A process for the conversion of hydrocarbon oils, which consists in heating a mass of relatively heavy hydrocarbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil before the cracking reaction reaches the condition where free carbon would be formed therein into a zone of lower pressure containing a separate mass of cooler hydrocarbon oil and checking the cracking reaction in said zone of lower pres-

sure before it reaches the condition where free carbon would be formed therein, in such a degree as to prevent the formation of free carbon in said zone by the simultaneous regulated introduction of a cooler hydrocarbon oil into said zone.

4. A process for the conversion of hydrocarbon oils which consists of heating a mass of relatively heavy hydrocarbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil before the cracking reaction reaches the condition where free carbon would be formed therein into a zone of lower pressure containing a separate mass of cooler hydrocarbon oil and checking the cracking reaction in said zone of lower pressure before it reaches the condition where free carbon would be formed therein, in such a degree as to prevent the formation of free carbon in said zone by intimately intermixing cooler oil drawn from said separate mass of cooler hydrocarbon oil with said heated oil in said zone of lower pressure.

5. A process for the conversion of hydrocarbon oils, which consists in heating a mass of relatively heavy hydrocarbon oil to a cracking temperature above the boiling points of the complex chemical constituents of said heavy oil under sufficient pressure to prevent vaporization of said chemical constituents, introducing said heated oil before the cracking reaction reaches the condition where free carbon would be formed therein into a zone of lower pressure in such a manner as would permit vaporization and cracking of said chemical constituents, and checking the vaporization and cracking of said heated oil in said zone of lower pressure before said cracking reaction reaches the condition wherein free carbon would be formed therein, by the simultaneous regulated introduction of a cooling agent into said zone of lower pressure at the point of introduction of said heated oil.

6. A process for the conversion of hydrocarbon oils, which consists in heating a mass of relatively heavy hydrocarbon oil to a cracking temperature above the boiling points of the complex chemical constituents of said heavy oil under sufficient pressure to prevent vaporization of said chemical constituents, introducing said heated oil before the cracking reaction reaches the condition where free carbon would be formed therein into a zone of lower pressure in such a manner as would permit vaporization and cracking of said chemical constituents and checking the vaporization and cracking in said zone of lower pressure before the condition is reached where free carbon would be formed therein, in such a degree as to prevent the formation of free carbon in said zone of lower pressure by the regulated introduction of a cooler mass of hydrocarbon oil at the point of introduction of said heated oil.

7. A process for the conversion of hydrocarbon oils, which consists in heating a mass of relatively heavy hydrocarbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging such heated oil before the cracking reaction reaches the condition where free carbon would be formed therein, into a zone of lower pressure containing a separate mass of cooler hydrocarbon oil, checking the cracking reaction in said zone of lower pressure before it reaches the condition where free carbon would be formed therein, in such a degree as to prevent the formation of free carbon in said zone of lower pressure by the simultaneous regulated intermixture of a cooler hydrocarbon oil with said heated oil and introducing the mixture thus formed into said separate mass of cooler hydrocarbon oil, separating out the resultant vaporized and uncondensed products and subjecting them to fractional condensation.

8. A process for the conversion of hydrocarbon oils, which consists in heating a mass of relatively heavy hydrocarbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil before the cracking reaction reaches the condition where free carbon would be formed therein, into a zone of lower pressure containing a separate mass of cooler hydrocarbon oil, checking the cracking reaction in said zone of lower pressure before it reaches the condition where free carbon would be formed therein, in such a degree as to prevent the formation of free carbon in said zone of lower pressure by the simultaneous regulated intermixture of a cooler hydrocarbon oil with said heated oil and introducing the mixture thus formed into said separate mass of cooler hydrocarbon oil.

9. A process for the conversion of hydrocarbon oils, which consists in heating a mass of relatively heavy hydrocarbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil before the cracking reaction reaches the condition where free carbon would be formed therein, into a zone of lower pressure containing a separate mass of cooler hydrocarbon oil, checking the cracking reaction in said zone of lower pressure before it reaches the condition where free carbon would be formed therein, in such a degree as to prevent the formation of free carbon in said zone of lower pressure by the simultaneous regulated intermixture of a portion of oil withdrawn from said separate mass of cooler hydrocarbon oil with said heated oil, separating out the resultant vaporized and uncondensed products, subjecting said vaporized and uncondensed products to fractional condensation, and returning a portion of the condensates of said fractional condensation to said mass of cooler oil.

10. A process for the conversion of hydrocarbon oils, which consists in heating a mass of relatively heavy hydrocarbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil before the cracking reaction reaches the condition where free carbon would be formed therein into a zone of lower pressure, containing a separate mass of cooler hydrocarbon oil, checking the cracking reaction in said zone of lower pressure before it reaches the condition where free carbon would be formed therein, in such a degree as to prevent the formation of free carbon in said zone of lower pressure by the regulated intermixture of a cooler hydrocarbon oil with said heated oil, separating out the vaporized and uncondensed products of such intermixture, subjecting said vaporized and uncondensed products to fractional condensation, and returning a regulated portion of the condensates of said fractional condensation to said separate mass of cooler oil in order to maintain said mass in the desired condition of solution and at a temperature such as will prevent the production of free carbon therein.

11. A process for the conversion of hydrocarbon oils, which consists in heating a mass of relatively heavy hydrocarbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil into a zone of lower pressure before the cracking reaction reaches the condition where free carbon would be formed therein, intermixing said heated oil with a mass of cooler hydrocarbon oil within said zone in order to check said cracking reaction in such a degree as to prevent the formation of free carbon therein, separating out the vaporized and uncondensed products of such intermixture, subjecting said vaporized and uncondensed products to fractional condensation, returning a regulated portion of the condensates of said fractional condensation to said mass of cooler oil, mixing a separate portion of said fractional condensates and a separate mass of fresh oil, returning the mix-

ture of said fresh oil and condensates to the heating step of the cycle of treatment and separating out the condensates desired as final products.

12. A process for the conversion of hydrocarbon oils, which consists in heating a mass of relatively heavy hydrocarbon oil to a cracking temperature under a pressure sufficient to prevent vaporization thereof, discharging said heated oil before the cracking reaction reaches the condition where free carbon would be formed therein into a zone of lower pressure having a separate mass of cooler hydrocarbon oil therein, checking the cracking reaction in said zone of lower pressure before it reaches the condition where free carbon would be formed therein, in such a degree as to prevent the formation of free carbon in said zone of lower pressure by the regulated intermixture of a cooler hydrocarbon oil with said heated oil, introducing the resultant mixture of oils into said separate mass of cooler oil, separating out the vaporized and uncondensed products of such intermixture and maintaining said separate mass of cooler oil at such a temperature as will prevent the formation of free carbon therein.

13. A process for the conversion of hydrocarbon oils which consists in heating a mass of hydrocarbon oil to a cracking temperature in such a manner as to cause a cracking reaction therein under an externally applied pressure sufficient to prevent vaporization thereof, directly discharging said heated oil into an enlarged zone of lower pressure before the cracking reaction reaches the condition where free carbon would be formed therein, and simultaneously therewith checking said cracking reaction in said enlarged zone of lower pressure by a reduction in temperature of said heated oil in such a degree as to prevent free carbon formation in said zone of lower pressure.

Signed at Chicago, Illinois, this 18th day of November, 1924.

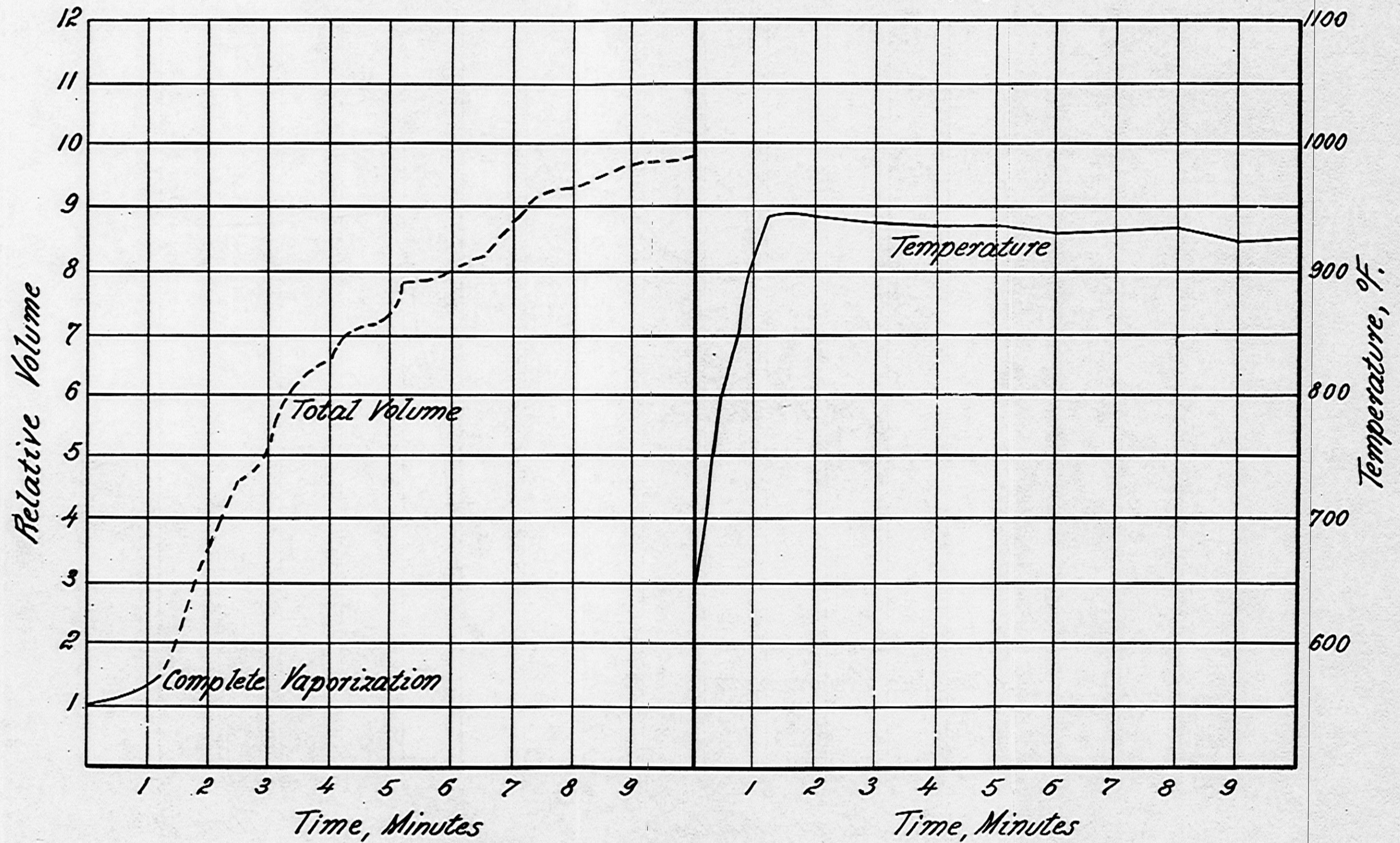
JOSEPH F. DONNELLY.



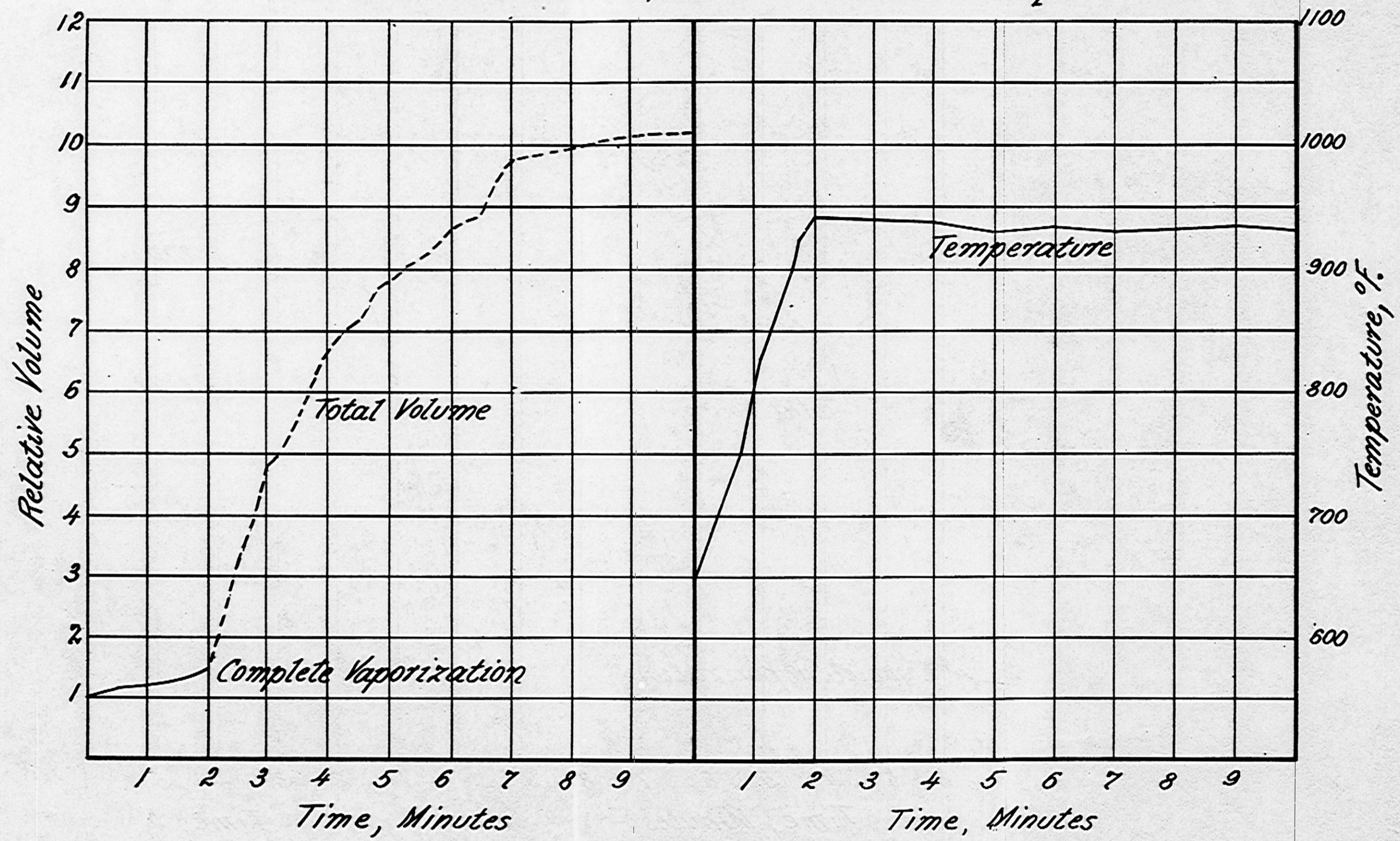
FIGURE 1

DATE	REVISED	REMIT ALL PRINTS BEING CANCELLED DATE	DRAWN BY TRACED BY APP BY APP BY APP BY FOR GENERAL MANAGEMENT DRAWINGS ONLY LOCATION ADDED BY GENERAL DESIGN APPROVED BY BY SPECIAL INSPECTION	AUTHORIZATION NO.		SINCLAIR REFINING CO. NEW YORK	
				REFINERY UNIT	SCALE DATE	DR. NO.	1935

Characteristics of cracking still heater feed under cracking conditions
611 Still heater feed Sample 9324-50 Pressure 600#/sq.In. Run 1

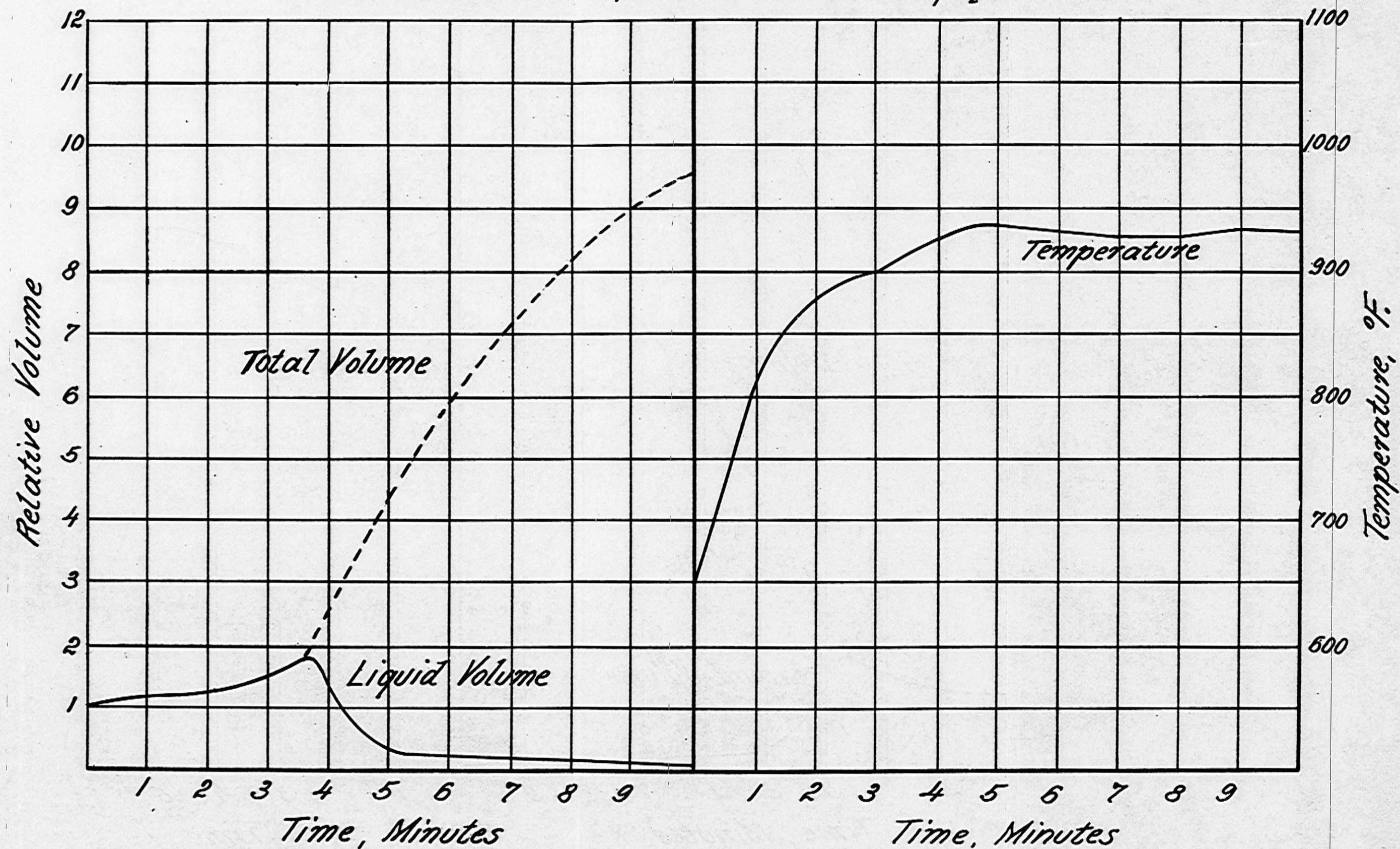


*Characteristics of cracking still heater feed under cracking conditions
611 Still heater feed Sample 9324-50 Pressure 600#/sq.In. Run 2.*

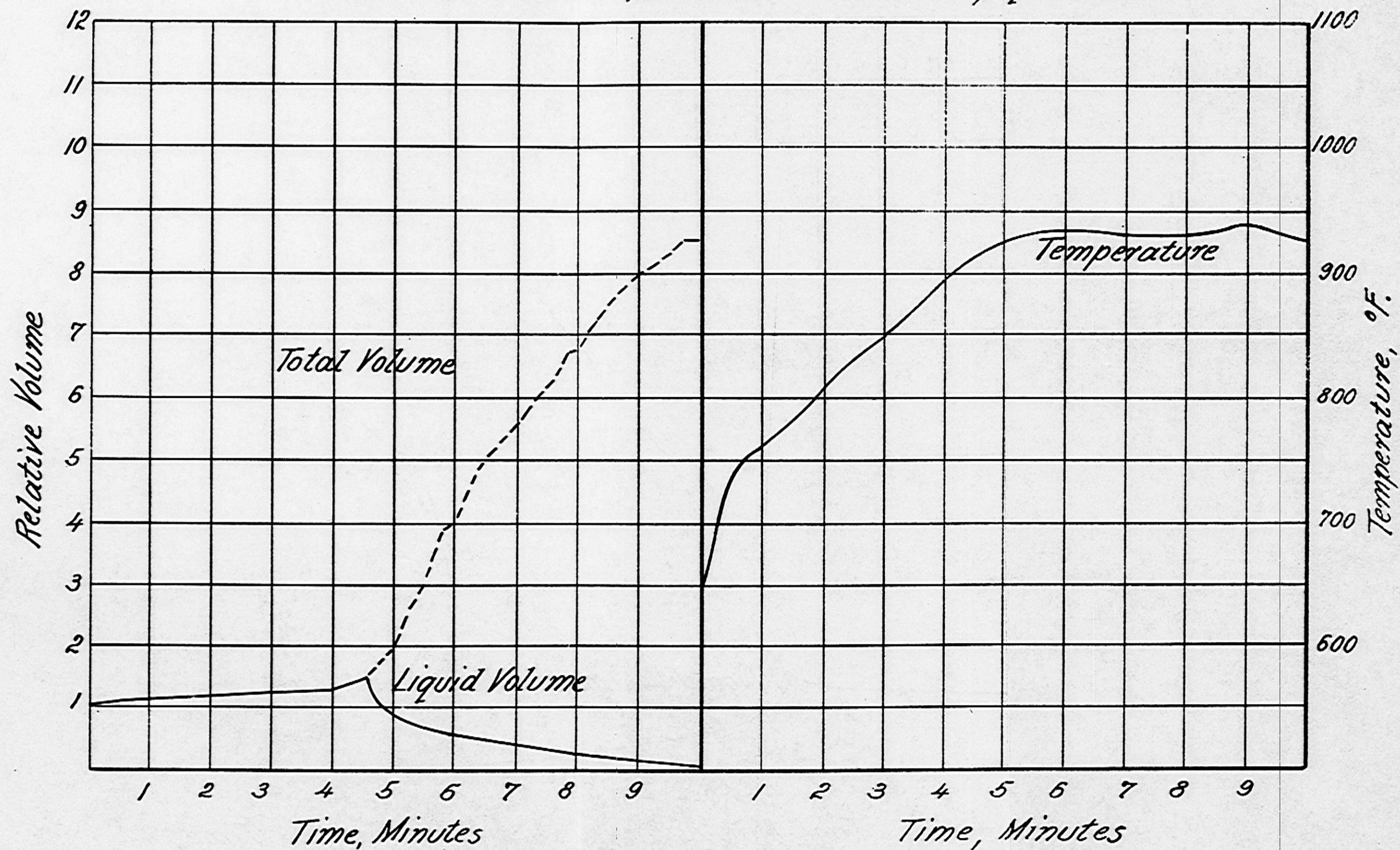


Characteristics of cracking still heater feed under cracking conditions

611 Still heater feed Sample 9324-50 Pressure 600#/sq.in. Run 3



*Characteristics of cracking still heater feed under cracking conditions
611 Still heater feed Sample 9324-50 Pressure 600#/sq.In. Run 4*



Plaintiff's Exhibit 18

181 INITIAL VAPORIZATION POINT FROM
PVT DATA.

<i>Run</i>	<i>Press.</i>	<i>Time (a)</i>	<i>°F</i>
1	600#/sq. in.	1.25 min.	945
2	600	2.00	940
3	600	3.60	915
4	600	4.55	915

(a) Time after reaching 650° F.

Plaintiff's Exhibit 19

182 #611 STILL OPERATING DATA AT NOON
JUNE 1, 1936.

No. 1 Heater In	633° F.	740#/sq. in.
No. 2 Heater In	885° F.	640-690#/sq. in.
No. 2 Heater Trans.	925° F.	Release 400#/sq. in.

<i>Streams</i>	<i>B/Stream Day</i>			<i>Distillations</i>		
	<i>B</i>	<i>%</i>	<i>°API</i>	<i>10%</i>	<i>50%</i>	<i>90%</i>
Dist. OH	3060	29.7	58.9	148°F.	276°F.	377°F.
#2 Twr. S. S.	2450	23.8	37.8	405	458	508
Rel. Gas	470	4.6				
Tar	1450	14.1	10.2	Initial = 460		
Total	7430	72.2				
Gas Oil	7433	72.2	34.4	387	579	80%=692
Htr. Thru-						
put (x)	10301	100.0	26.3	533	614	80%=678

(x) Sample 9324-50

FROM DEFENDANT'S EXHIBIT 1

(Gard et al. Patent No. 1,914,914.)

June 20, 1933.

E. W. GARD ET AL

1,914,914

METHOD FOR VAPOR PHASE CRACKING OF OIL

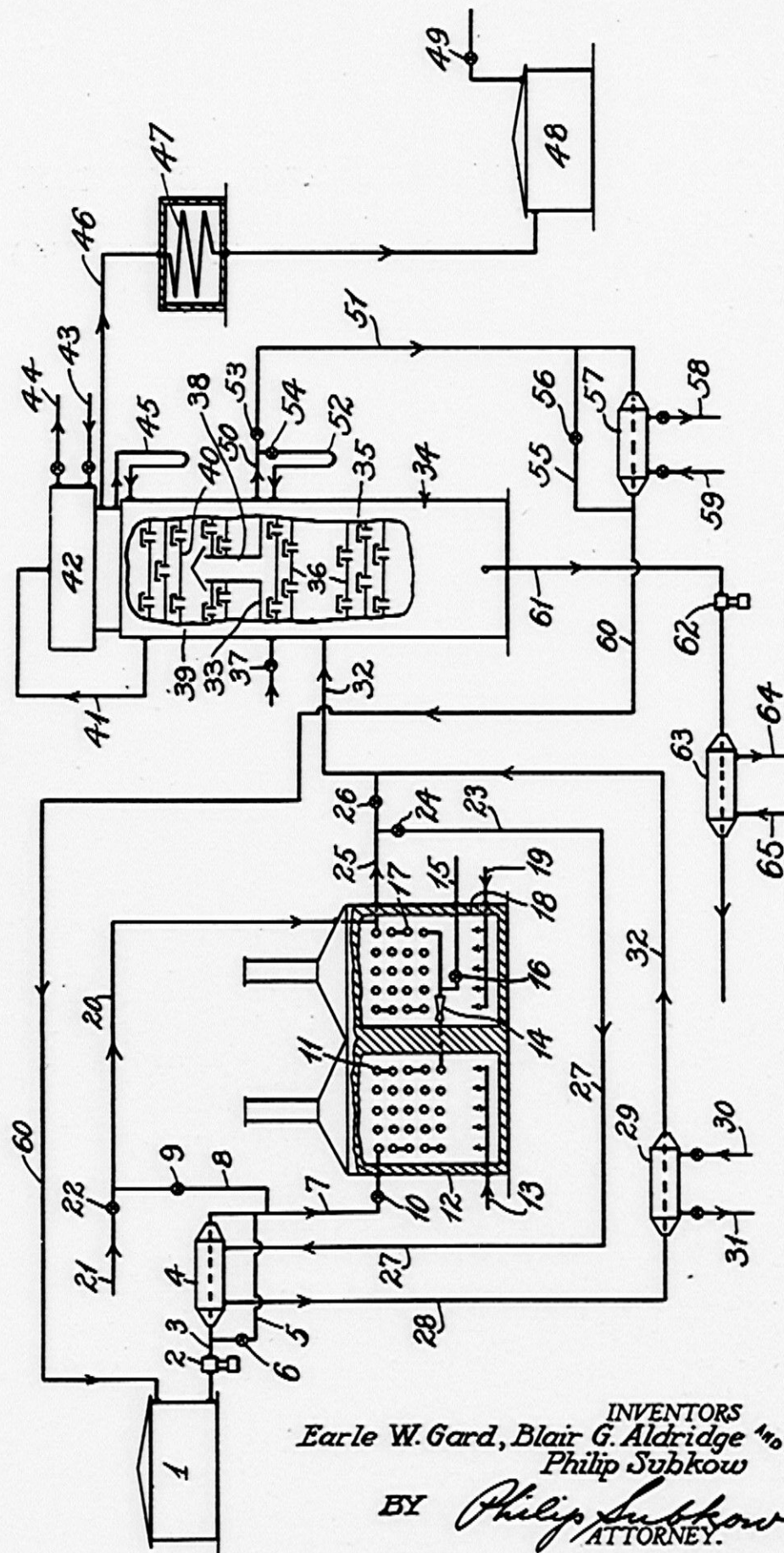
Filed April 23, 1929

3 Sheets-Sheet 1

Fig. 2.



Fig. 1.



INVENTORS
Earle W. Gard, Blair G. Aldridge
Philip Subkow

BY *Philip Subkow*
ATTORNEY.

June 20, 1933.

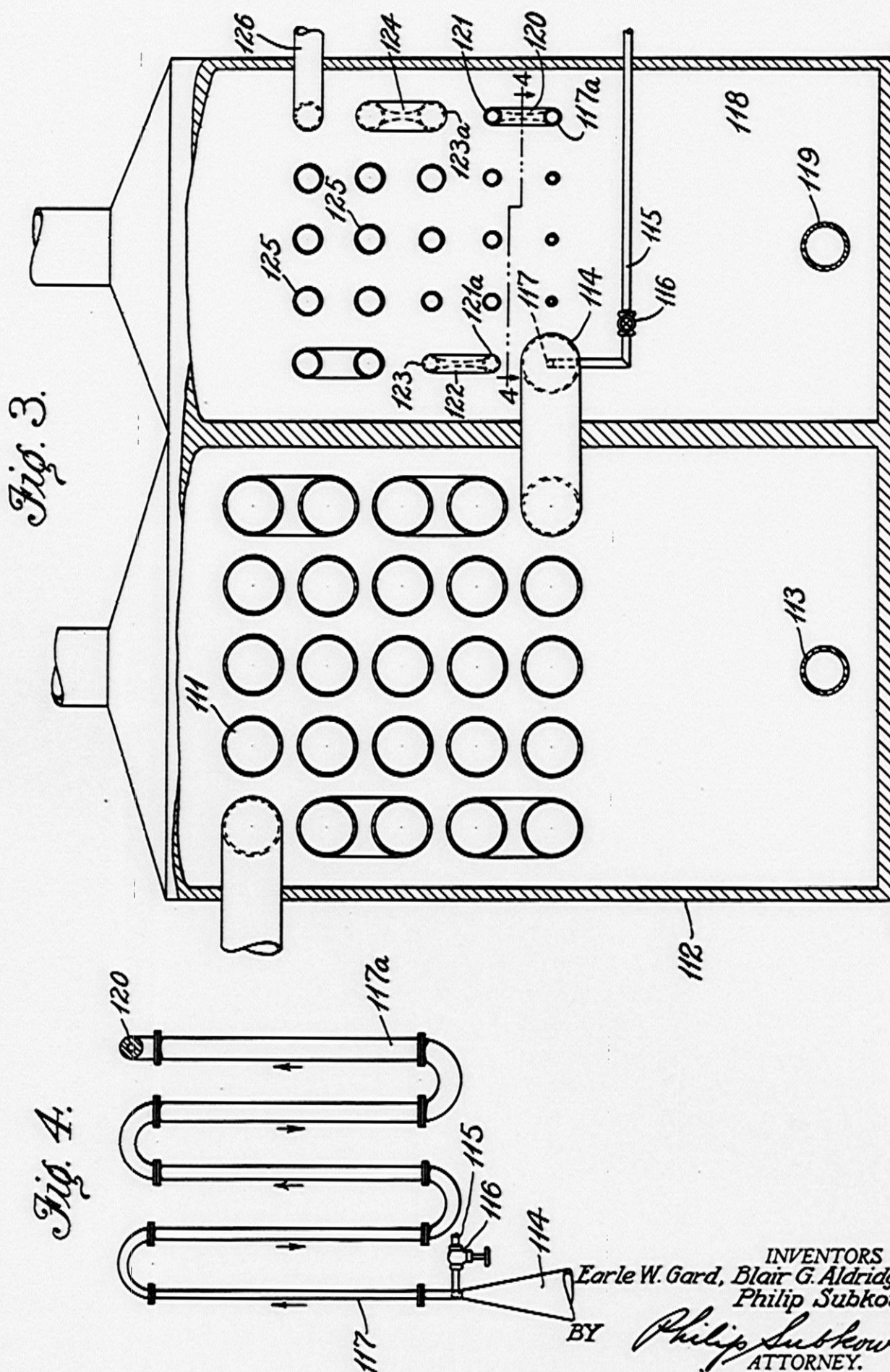
E. W. GARD ET AL

1,914,914

METHOD FOR VAPOR PHASE CRACKING OF OIL

Filed April 23, 1929

3 Sheets-Sheet 2



June 20, 1933.

E. W. GARD ET AL

1,914,914

METHOD FOR VAPOR PHASE CRACKING OF OIL

Filed April 23, 1929

3 Sheets-Sheet 3

Fig. 5.

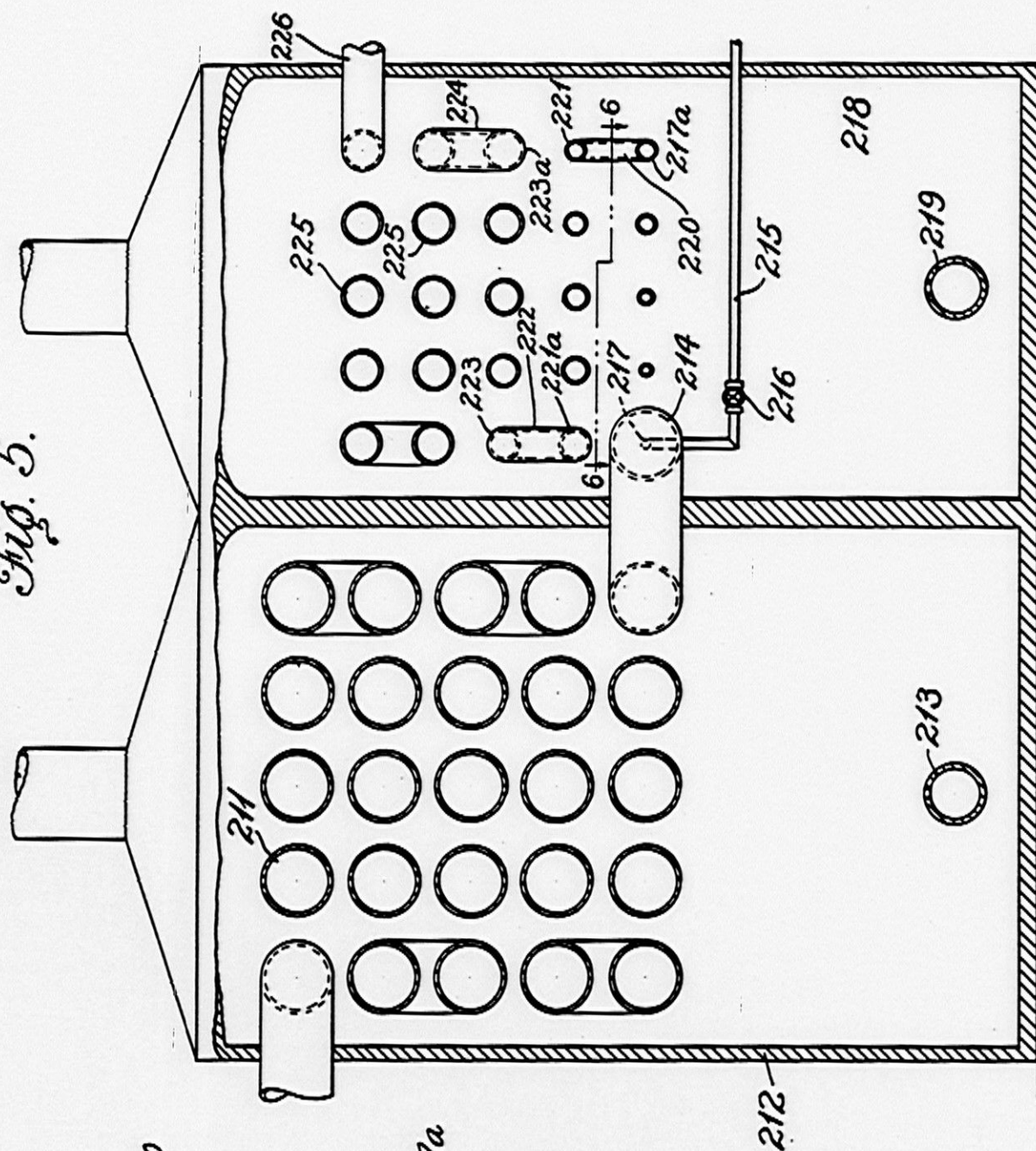
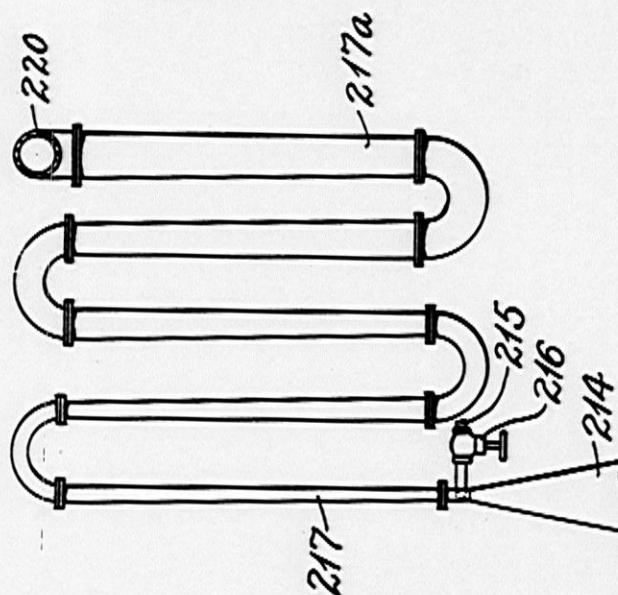


Fig. 6.



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METHOD FOR VAPOR PHASE CRACKING OF OIL

Application filed April 23, 1929. Serial No. 357,471.

This invention relates to a process of cracking oil and particularly to a process of cracking oil in the vapor phase.

It is an object of this invention to obtain extremely high velocity of vapors through tubular cracking coils and to insure that the vapors passing through the cracking coils are substantially free of entrained liquid, and to operate the process at maximum heat efficiency.

We have found that among the elements conducive to efficient vapor phase cracking are that the vapors passing through the vapor cracking coils must be uniformly heated. In order to obtain this, high vapor velocities are necessary. In order to get good heat conduction to the interior of the moving core of vapor, high turbulence is desirable. In order to obtain conditions wherein no carbon deposit occurs it is essential that no liquid enters into the highly heated vapor phase cracking coils. If liquid does so enter, high temperature distillation of the liquid occurs with consequent coking. An additional advantage of high vapor velocity is that it acts to scour the tubes to remove from the tubes any deposited carbon and to carry it out with the vapor stream.

It is well known that heating efficiency is greater when the oil is heated in the liquid phase. We, therefore, propose to heat the oil to its cracking temperature in the liquid phase and then to expand the heated oil into the vapor phase cracking tubes operated without any back-pressure except the frictional resistance to the flow of the vapors to the tubes.

In order to insure that no liquid enters into the vapor phase cracking coils, it is proposed to heat the oil under high pressure to a temperature such that complete vaporization occurs. Thus the oil is heated above its maximum boiling point at the pressures employed and then expanded into the vapor phase cracking coil. In the preferred form the oil is heated to a temperature at least as high as the critical temperature of the oil at the point of expansion of the oil into the vapor phase cracking coils.

It is well known that there is a critical

temperature above which, no matter how large the pressure, liquids or mixtures of liquids such as petroleum oils cannot remain in the liquid state. This temperature is known as the "critical temperature". This temperature is determined by the well known meniscus method in which the liquid is heated in a sealed tube, which is partially filled with the liquid. The temperature at which the meniscus which constitutes the level of the liquid disappears, is the critical temperature of the liquid. Certain investigators have shown that there is a relationship between the average boiling point of petroleum oil and the critical temperature, and have evolved the following formula. The average boiling point, T_b , is defined as the average obtained by averaging the temperature at which the first drop comes over with that recorded for each 10 cc cut in the standard A.S.T.M. distillation. The critical temperature T_c is then expressed by the following:

$$T_c = 1.05T_b + 160$$

While this formula has been shown to represent the critical temperature as observed by the meniscus method with great accuracy, the experimental determination of this critical temperature is the most desirable one. This is because many oils contain other than straight chain hydrocarbons, for which the above formula is designed. Thus, for instance, the equation for pure aromatic hydrocarbon is:

$$T_c = T_b + 208$$

where T_b is the boiling point of the pure aromatic hydrocarbon. Many petroleum oils fall between the two formulas, indicating the existence of aromatics in the oil. It will, therefore, be desirable to determine the critical temperature of the oil experimentally.

The critical temperature of the oil is changed by heating, for, in bringing oil to the critical temperature some incidental cracking may occur, generating lighter hydrocarbons which lower the critical temperature. However, if the oil is heated under very high pressure to at least the critical temperature of the initial oil, it will be safe

to assume that the oil when it reaches the temperature found to be the critical temperature of the original oil, it will be entirely in the vapor phase.

5 It is, therefore, an object of this invention to heat oil to its critical temperature and under high pressure and to flash the vapors into a vapor phase cracking coil to permit the expansion of the vapors and high velocity travel during cracking.

10 It is, therefore, another object of this invention to heat oil under high pressure substantially such to keep the oil in a liquid phase until the oil reaches a condition such
15 that it is substantially entirely converted into vapor, that is, heating the oil under high pressure in liquid phase to the critical temperature of the heated oil and then flashing the vapors from this region of high pressure through a coil on which the only back
20 pressure is the frictional resistance to the flow of the vapors through the coil and heating the vapor passing through the coil to crack them in the vapor phase, to produce
25 an unsaturated, anti-knock gasoline.

The invention will be better understood by reference to the drawings which show a schematic form of an apparatus for carrying out this invention.

30 Fig. 1 is a schematic form of the complete apparatus.

Fig. 2 is a detail view of the venturi shown in Fig. 1.

35 Fig. 3 is a more detailed view of one form of furnace and tube construction shown in Fig. 1.

Fig. 4 is a detail of tubes shown as taken on line 4-4 of Fig. 3.

40 Fig. 5 is another form of furnace and tube construction as used in apparatus illustrated in Fig. 1.

Fig. 6 is a detailed view of the tube structure shown as taken on line 6-6 of Fig. 5.

45 Oil, such as gas oil, contained in tank 1, is passed by pump 2, through line 3, and heat exchanger 4, regulated by a by-pass 5, controlled by valve 6, into line 7. Oil may be by-passed through line 8, controlled by valve 9, as will be further described. The
50 oil passed through line 7, controlled by valve 10, is passed through coils 11, situated in furnace 12, heated by burners 13. Oil is then passed through a Venturi throat 14, shown in Fig. 2, wherein it may meet a jet of high
55 temperature steam or gas admitted through line 15, controlled by valve 16. The oil is then introduced into coil 17, positioned in furnace 18, heated by burners 19. On exiting from the coils 17, the heated oil meets
60 oil injected through line 20. Additional media to function in an analogous manner may be injected. Additionally, gas may be introduced as will be understood by those skilled in the art. This oil from line 20 may
65 be the oil by-passed through line 8, and/or

additional oil introduced through line 21, controlled by valve 22. The oil passing through line 25, is passed through valve 24, in line 27. The passage may be controlled by by-pass valves 26. The vapor from line
70 27, passes through heat exchanger 4, and through line 28, into cooler 29, cooled by cooling fluid introduced at 30, and exiting at 31.

75 The partially cooled vapors are then introduced, through line 32, into fractionating column 34. Fractionating column 34, is divided into a stripping section 35, and a fractionating section 39. Vapors from 35, are partially condensed and collected on 33,
80 by passage through bubble cap plates 36, where they meet, counter-currently, condensate introduced through 52, as will be further described, and the additional cooling fluid introduced when desired through 37.
85 Steam may be introduced in 35, to aid stripping and reboiling. The uncondensed vapors pass through throat 38, into the fractionating column 39, where they pass through bubble plates 40. The condensate formed on
90 those plates is collected in deck 33, to be withdrawn through 50, as will be later described. The uncondensed vapors pass through 41, downwardly through dephlegmator 42, cooled by the cooling fluid entering at 43, and exiting
95 at 44. The uncondensed vapors exit through 46, and are condensed in condenser 47, collected in run-down tank 48 and the fixed gases are vented through 49. The condensate formed in 42, is withdrawn through
100 trap 45, and introduced on the top plate in the fractionating section 49. The condensate collecting on deck 40, is withdrawn through 50, part is by-passed through valve 54 and trap 52, into the stripping section and part
105 is sent through valve 53, and line 51, to cooler 57, cooled by a cooling fluid introduced at 59, and exiting at 58, and controlled by by-pass 55, in which there is a valve 56. The cooled condensate is passed through
110 line 60, back into the tank 1. The unvaporized fraction is withdrawn through line 61, by pump 62, passed through a cooler 63, into which a cooling fluid circulates via 65, and 64, and sent to storage.
115

Figs. 3, and 4, show in more detailed form one construction of the heating units.

The function of this type of heater is to permit the gradual expansion of the high pressure vapors in order that heat may be
120 imparted as the vapors expand so that the excessive cooling resulting from expansion is prevented. It will be observed that the coils in the vapor phase furnace 118, are smaller than the high pressure coils in furnace 112. In furnace 112, heated by burners
125 113, the coils are composed of straight tubes with return bends to form a continuous coil.

It will be observed that in furnace 118, heated by burners 119, the coils are composed
130

of banks increasing in size in direction of flow of the vapors. The oil passes from 111, into a constriction 114, which joins with a narrow tube 117. Each tube is of constant diameter, but on the lowest row the tubes from 117, to 117a, are increasing in diameter. Vapors passing from tube 117a, cross over to 120, into tubes 121 to 121a. These tubes are of constant diameter, that is, all the tubes in the row are of the same diameter. The vapors then pass into a cross-over 122, into tubes 123, to 123a. Each tube is of the same diameter, but the tubes increase in diameter across the bank in the direction of flow of the vapors. Vapors then pass into cross-over 124, and into tubes 125. All of the tubes 125, are of constant diameter, and the oil finally exits in 126. This drawing is entirely schematic to illustrate the invention. The tube banks may be increased in number and the tubes in the banks increased in number and size and the variations of size are a matter of design depending on the amount, character of the oil processed and the temperatures and pressures. The essential idea is to permit gradual expansion of the vapors. Means for introducing heated gas is shown at 115, controlled by 116, to aid in heating the gases and increasing their velocity.

It will be advisable also, to provide a plurality of Venturi throats between each section of tube so that the expansion shall be insured to occur in stages. Thus a Venturi throat may be introduced in the cross-over valves 120, 122, 124, as see Fig. 3. The several venturi are so designed to maintain a regulated pressure which is reduced in the direction of flow of the vapors. This is a matter of design as will be understood by those skilled in the art.

Fig. 5 shows another variation of the heating furnace.

As before, 212, is the high pressure furnace in which are positioned high pressure coils 211, heated by burners 213. The vapor phase cracking furnace 218, is heated by burners 219. The oil passing from coils 211, is passed through the constriction 214, and into the tubes 217, to 217a. The tubes in this bank increase in size uniformly in the direction of the flow; that is, each tube increases in size, and each tube is of greater diameter than the preceding tube. The oil passing from 217a, passes to cross-over 220, into the tubes 221, to 221a. As previously described, each tube increases in size uniformly in the direction of the flow and each succeeding tube is greater than the preceding one, tube 221, is greater than tube 217a; that is, the tubes are of cone shape; that is, the exit of the tube 217a, is smaller than the entrance of tube 221. The oil passes through cross-over 222, into the tube 223, to 223a. These tubes increase in size in the same manner as previously de-

scribed. The oil is passed through cross-over 224. It enters tubes 225, which are all of the same diameter in the direction of flow of the vapors and exiting at 226. It will be seen that tubes 217, to 223a, constitute an elongated Venturi tube, permitting gradual expansion of the vapors during which expansion heat is imparted to make up for the cooling incidental to expansion. Means are provided for the introduction of hot gases by means of line 215, controlled by valve 216, to aid in heating the gases and increasing their velocity.

The forms of furnaces here shown permit for the expansion of the gases gradually so that heat may be imparted to them as they expand, to compensate for the temperature drop. This also permits a rapid heating of the oil to its cracking temperature. This is desirable for a greater proportion of the gasoline formed is true vapor phase cracked gasoline. It is obvious, however, that since the vapors were at or above their critical temperature before expansion, there will be no condensation in any form of design here shown. The vapors will always be superheated at their lower pressure, that is, they will be above the temperature at which the vapors are saturated at the lower pressures. However, since a drop in temperature will inhibit the vapor phase cracking reaction, the imparting of the heat will maintain them at the high cracking temperatures desired for vapor phase cracking and prevent the necessity of imparting a very intense heating at the exit to the Venturi throat. It will be observed that the neck of the constriction of 14, 114, and 214, respectively, are the throats of the venturi or modified venturi, respectively.

The operation of the process will be explained below, with reference to a specific example, given by way of illustration.

Assuming that we are operating on a California gas oil having a gravity of 27.8° A. P. I., and an average boiling point of 547° F. the oil is pumped from tank 1, (Fig. 1) through the pre-heater 4, and introduced into coil 11, under a pressure of about 1,000 to 2,000 pounds. The oil is heated in coil 11, to a temperature above 862° F., which is the critical temperature of the oil in tank 1. It will be sufficient to heat the oil to about 875° F. At this temperature the oil is entirely in vapor phase before it reaches the expansion point 14. The oil is expanded into coil 17, valve 24, being wide open, valve 26, is closed. The coil 17, is heated to a temperature sufficient to raise the vapor passing through the coil to a temperature above 1,000° F., and is heated in coil 17, for a period of time sufficient to give the proper conversion, about 50%. The cracking temperature may be between 900 to 1,500° F., depending on the rate and amount of conversion desired, as will be

understood by those skilled in the art. At the point of exit from coil 17, these vapors meet oil introduced through 21, or 8, via line 20, in amount and temperature sufficient to considerably cool the vapors and coalesce carbons or tars formed in the cracking. Approximately 20 to 30% of injection oil is thus introduced.

The co-mingled oil and vapor pass through heat exchanger 4, and cooler 29, and there introduced into a fractionating equipment at a temperature of about 650° F. By-pass 26, may be operated to regulate the heat exchanger 4, and cooler 29. The vapors introduced into 34, via 32, are stripped of the heavy fractions in 35, and the vapors passed into fractionator 39, where they are fractionated by means of the reflux introduced through 45, as explained, to produce a gas oil fraction, part of which is introduced into 35, via 52, and the remaining portion passed through cooler 57, into stock tank 1, to be re-cracked. The uncondensed fraction issuing through 46, is condensed from 47, and collected in 48. Uncondensable gas is being withdrawn from 49.

If desired, valve 24, and/or 26, may be partially closed to control the rate of passage of the vapors through 17, if an increased time is desired in the coils. Ordinarily it would be preferable to design the length of coil sufficient to give the necessary time to operate with no back-pressure on the coil, except that of resistance to flow. In the forms illustrated in Figs. 3 and 5, the coils are designed to permit the gradual expansion of the vapors so that heat may be imparted to them as they expand and the drop in temperature necessarily resulting on expansion, is mitigated and the rate at which the oil is raised to its cracking temperature, 1,000° F. and over, is increased. It is desirable to raise the vapors to that temperature as quickly as possible. The operation of the modification shown in 3 and 5 will appear from what has been previously said.

The above description is not to be taken as limiting our invention but merely as illustrative of the invention and the best mode of carrying it out. Many changes can be made within the scope of this invention, which we claim to be:

1. A method of cracking oil which comprises heating oil in a flowing stream under high back pressure sufficient to maintain the liquid phase up to its critical temperature, completely vaporizing said oil under said high pressure then substantially releasing the back pressure on the flowing stream and expanding said oil vapors through a heated zone to crack said oil in the vapor phase.

2. A method of cracking oil which comprises heating oil while flowing through a coil to completely vaporize said oil under high pressure sufficient to maintain the liquid

phase up to its critical temperature and then substantially releasing said pressure and expanding said oil through a coil under reduced pressure and heating said expanded oil to crack said oil in the vapor phase.

3. A method of cracking oil which comprises passing oil through a heated coil under high pressure sufficient to maintain the liquid phase up to its critical temperature, completely vaporizing said oil in said coil under said high pressure, then substantially releasing said pressure and expanding the vapors through a heated zone to crack said vapors under reduced pressure.

4. A method of cracking oil which comprises passing oil through a coil under high pressure sufficient to maintain the liquid phase up to its critical temperature, heating the oil in said coil to at least its critical temperature, then substantially releasing said pressure and expanding the vapors thus formed through a second coil, heating said second coil to a high temperature sufficient to crack the oil in the vapor phase.

5. A method of cracking oil which comprises heating the oil in a flowing stream in a coil under high pressure sufficient to maintain the liquid phase up to its critical temperature, raising the temperature of the oil to at least its critical temperature and then substantially releasing said pressure and expanding the vapors through a heated zone to crack said vapors under a reduced pressure.

6. A method of cracking oil which comprises heating oil in a flowing stream, completely vaporizing said oil under high pressure sufficient to maintain the liquid phase up to its critical temperature and then substantially releasing said pressure and gradually expanding said vapors through a heated zone to crack said vapors in the vapor phase.

7. A method of cracking oil which comprises heating oil while flowing through a coil to completely vaporize the oil under pressure sufficient to maintain the liquid phase up to its critical temperature and then substantially releasing said pressure and gradually expanding the oil through a heated zone to quickly raise the oil to a sufficiently high temperature to crack said oil in the vapor phase.

8. A process for cracking oil to produce unsaturated and anti-knock gasoline which comprises rapidly heating oil in a flowing stream under a super-atmospheric pressure to the critical temperature of said oil, said pressure being sufficient to maintain the oil in substantially liquid state up to its critical temperature, vaporizing the oil while under said pressure to form a vapor free of liquid particles and then substantially releasing said pressure and introducing said vapors free of liquid particles into a vapor-phase cracking coil and expanding the vapors through said vapor-phase cracking coil at

high velocity and under a condition of high turbulence, heating said vapors in said vapor-phase cracking coil to a high cracking temperature of 900° F. and above and sufficient to
5 form said unsaturated and anti-knock gasoline and controlling the temperature and rate of heat in the vapor-phase cracking stage to produce the greater part of all of said gasoline produced during said process during said
10 cracking stage.

Signed at Los Angeles, in the county of Los Angeles, and State of California, this 13th day of April, A. D. 1929.

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FROM DEFENDANT'S EXHIBIT 1

(Peck Patent No. 1,933,507.)

UNITED STATES PATENT OFFICE

1,933,507

CRACKING IN HOMOGENEOUS STATE

Edward B. Peck, Elizabeth, N. J., assignor to
Standard Oil Development Company, a corpo-
ration of Delaware

Application August 21, 1929. Serial No. 387,339

3 Claims. (Cl. 196—58)

This invention relates to improvements in cracking hydrocarbon oils, and relates to a cracking under conditions precluding the separation of the oil into liquid and vapor phases of different composition during the heating and the soaking periods, that is, during the time the stock is heated up to cracking temperature and kept at cracking temperature.

One object of the invention is to provide a cracking process in which the deposition of coke is greatly diminished.

Another object is to insure an equal flow of the oil in the heating tubes (cracking coil).

A further object is to crack the oil at higher temperatures than have hitherto been used in purely liquid phase cracking processes and to reduce the time and decrease the size of the apparatus necessary for a certain amount of cracking.

A still further object of this invention is to provide a cracking process in which higher conversions to cracked products can be obtained than in purely liquid phase cracking processes.

One aspect of my process provides for the addition of an intermediary stock, such as kerosene, to the heavy cracking stock, to reduce the pressure under which the process has to be carried out.

Further objects will be apparent and the invention will be fully understood from the following description, read in connection with the accompanying drawing, in which the figure is a vertical diagrammatic section through suitable equipment.

Pure substances have a critical point which is the end of the vapor pressure curve. The critical temperature for a pure substance is the temperature above which no liquid state can exist and corresponds to a definite pressure and volume at the critical temperature. It is a matter of thermodynamic and experimental proof that no such unique point can exist for a mixture but rather a zone with variations increasing as the number of components in the mixture. Such variations are defined by the phase rule.

I have carried out experiments relating to the critical phenomena of various oil products over a period of several years and arrived at certain conclusions which will be readily understood from the following table:

Table.—Limits of critical data on petroleum products

No.	Sample	T Temp. °F.	Pressure lbs. sq. in.	Volume at T Volume at 60° F.
1.	Gas from cracking coil.....	46	1900	*0.0088
		120	1550	0.0080
2.	Gasoline 66° A.P.I.....	599	508	2.18
		635	495	4.38
3.	45° A.P.I. distillate from crack- ing coil.....	747	390	2.35
		780	383	4.82
4.	95% (2)+5% (3).....	616	515	2.05
		658	505	4.01
5.	90% (2)+10% (3).....	619	522	2.15
		666	517	4.20

* (Referred to gas under 1 atm. pressure.)

It is evident from this table that heavier oils show critical phenomena at higher temperatures and lower pressures, and that within the critical zone large volume changes occur for relatively small temperature changes. In other words, the oil is more elastic in the critical zone than in any other state. Another result from these and similar data is that the wider the distillation range the greater is the pressure required for the critical range. Obviously any product will be homogeneous (i. e. it will be present only in one phase) at temperatures below the critical range when the pressure is kept above the critical, or at any pressure when the temperature is above the critical range. For instance, the 45° A. P. I. distillate will be homogeneous at or below 747° F. at 390 lbs. sq. in. pressure and any pressure higher than that, provided no chemical change occurs. Similarly, it will be homogeneous under any pressure at temperatures of 780° F. or higher. The former is liquid state and the latter gaseous state.

The following tests may be applied to determine the state of an oil under certain conditions of pressure and temperature. If the pressure is dropped isothermally until a separate liquid and vapor phase appear and further drop in pressure causes boiling, the oil is in the liquid state. If, on isothermal pressure drop no meniscus appears, i. e. no separation into liquid and vapor phase takes place, the oil is in the gaseous state. The critical range may be recognized by the great elasticity of the oil. Separation in this range

is not gradual, as for normal liquid state, but occurs abruptly, with varying ratios of liquid and vapor, depending on the temperature and pressure. The critical zone is unique in that retrograde condensation may occur. If a gas is compressed at constant temperature within the critical range, normal condensation of liquid will occur with increase in liquid to vapor ratio. On increasing pressure this condition continues to a maximum formation of liquid, after which increase in pressure causes liquid to vaporize very rapidly.

Gas oil or other heavy stocks used as raw materials for cracking have their critical zone at high temperatures and comparatively low pressures. For instance, the critical zone of a 34° A. P. I. Mid Continent gas oil is well over 900° F. with pressures of the order of 250-300 lbs. sq. in. However, from 600° F. on, cracking takes place which becomes rapid at temperatures ranging above 800° F. and consequently light products are formed so that the pressure required for the critical state increases rapidly while the temperature range of the critical state decreases. After 10 minutes cracking at 850° F. the above gas oil will show critical phenomena at 750 lbs. sq. in. and I have found critical phenomena for highly cracked gas oil at a temperature of 780° F. and a pressure of 1750 lbs. sq. in.

I have discovered that the coke formation in cracking is greatly reduced and a smooth operation becomes possible when the cracking is carried out in such a manner that the oil is constantly in a homogeneous state during the periods of heating and soaking (cracking). For the sake of brevity we shall call such a process "cracking in the homogeneous state". A possible explanation of this circumstance during the cracking period is predicated on the fact that coke is a byproduct of polymerizing reactions. Such reactions being multimolecular are suppressed by dilution which is at a maximum when all the constituents are mutually dissolved. While multimolecular reactions are suppressed by dilution they are also accelerated by increase in pressure. If these factors were the only ones operating the coke reactions would be at a minimum at the lowest pressure for homogeneous state. I have found that coke formation is suppressed as the pressure is increased beyond that for homogeneous state. This is associated with a decided decrease in olefines in the light products and I have therefore concluded that coke formation is suppressed by the reaction of light olefines with the heavy polymerizable products. Again, if the oil separates into a vapor and liquid during the heating period, there will be an unequal flow, some of the liquid oil lagging behind and becoming burned (over-cracked) on the hot surface of the heating tubes.

There are two methods available for cracking in the homogeneous phase. First; cracking below the critical temperature range and increasing the pressure to such extent that the oil does not vaporize at all. In this case the oil remains liquid during the heating and the soaking periods, since the oil at the lower stages of conversion has lower critical pressure and higher critical temperature range. This method has the disadvantage that both the cracking temperature and the conversion to which the cracking proceeds must be kept comparatively low. Further, the low cracking temperature entails a considerable soaking time since the rate of cracking is very slow at low temperatures. The second meth-

od consists of cracking under such conditions of temperature and pressure that the oil is above the critical range or in the gaseous state in the final stage of cracking, that is, when the conversion required is attained. In the last mentioned case the oil must have passed from the liquid state into the gaseous one at some stage of the heating or the soaking period. Such transition is possible without evaporation but by uniform expansion from the cold liquid to the hot gaseous state. In this case the transition is homogeneous, i. e., the liquid oil will go over into the gaseous state without separating into a liquid and a vapor phase during the transition, and the application of this characterizes my invention. I have discovered that by proper regulation of the composition of the oil, temperature, pressure, and the heating rate, the cracking can be made homogeneous. For instance, if a 34° A. P. I. Mid Continent gas oil is cracked at 850° F. to a conversion of 35% by volume of gasoline under a pressure of 900 lbs. sq. in. it will be in the critical stage at 35% conversion to gasoline. Passing this conversion, two different phases, liquid and vapor, appear in the cracking vessel. At all lower conversions the oil is homogeneous and liquid, so that in this case the cracking will be homogeneous independently of the heating rate at which the oil was brought up to the cracking temperature, as long as the conversion to gasoline is kept below 35%.

Cracking the same gas oil at 850° F. and under 1000 lbs. sq. in. pressure, the oil will be in the critical stage at 38% conversion to gasoline and the cracking will be homogeneous at lower conversions, say 37%, independently of the time in which the oil was brought up to cracking temperature. The conditions are analogous in cracking under 750 lbs. sq. in. pressure (temperature 850° F.) in which case separation of liquid and vapor phase takes place at 25% conversion. At 850° F. and 350 lbs. sq. in. pressure, it is impossible to carry out the cracking in the homogeneous state and separation in liquid and vapor phase occurs at less than 1% conversion.

At higher temperatures it becomes easier to carry out the cracking in the homogeneous state. For instance, at 950° F. under 750 lbs. sq. in. pressure it is possible to carry the cracking far beyond the degree corresponding to the most strenuous cracking given above as example for the operation at 850° F., without observing a separation into liquid and vapor. At the beginning of the heating period the oil is in the liquid state and at the end of the cracking period it is in the gaseous state; the transition occurred through the critical stage in a continuous manner. In such cases the rate of heating becomes an important factor. Cracking will naturally take place during the time while the oil is heated up to 950° F.

If the heating up is effected in a short time so that the cracking is below the conversion of 25% gasoline when the temperature of 850° F. is reached, the cracking will be homogeneous. However, if the heating is carried out at a slow rate and the oil is allowed to crack to 25% gasoline conversion at a time when the temperature reached is 850° F. or lower, separation into liquid and vapor phase takes place suddenly when the conditions of composition temperature and pressure are satisfied. This separation may vary from almost all liquid to almost all vapor within slight changes of any of the variables. In this case the cracking has not been carried out in

the homogeneous phase and there is a danger of heavy coke deposition from the separated liquid phase.

At 925° F. a 34° A. P. I. Mid Continent gas oil can be cracked to the maximum of its practical conversion limit, i. e. 40% gasoline in the homogeneous state under 900 lbs. sq. in. pressure (or higher) if the rate of heating the oil to that temperature is not exceptionally slow. The conditions are about the same for other gas oils. At higher temperatures the pressure required for the maintenance of homogeneous state in cracking is lower, as illustrated in the above example° at 950°.

At a given cracking temperature the lighter oils require lower pressure than the heavy oils for cracking in the homogeneous state. Thus, for instance, kerosene can be cracked in the homogeneous state under a pressure of about 150 lbs. sq. in. lower than gas oil, other conditions being alike. I have also discovered that a mixture of gas oil and kerosene similarly requires much lower pressure for cracking in the homogeneous state than gas oil, in fact, this pressure comes near to that required by the kerosene. In general, I have observed that middle fractions, ranging between a heavy cracking stock and the gaseous and other light products resulting from the cracking, have a marked solvent effect on the heavy and light ends and consequently lower the pressure necessary for homogeneous phase cracking.

After the desired degree of cracking is obtained, the various products are separated by any suitable method known to the art. The separation does not form part of my invention and therefore it will be only briefly discussed. Various equipment known in the art may be used. I may use, for instance, the apparatus and the method of separation described in U. S. patent application Serial No. 178,547 of John S. Harrison.

Referring to the drawing, the apparatus and the process will be jointly described.

The feed is charged by means of the high pressure pump 25 through line 26 to the cracking coil, consisting of a series of tubes 1 arranged in a furnace 2, and thence through line 3 into the soaking drum 4. The cracked products leave the latter by line 5 and after passing through the tar separator 6 they are discharged through line 10 and spray head 11 into the accumulator 12. Release valves 7 and 10' allow the maintenance of the desired pressure on the soaking drum and on the tar separator independently. The separated tar leaves by line 8, is cooled in 9 and stored in a suitable tank. Fresh feed is charged into the accumulator through line 13. Any desired fraction of the fresh feed may be passed through coils 14 whereby a certain amount of preheat is obtained. The heavy uncracked hydrocarbons condense in the accumulator and are returned together with the fresh feed to cracking coil 1 while the distillate leaves through line 17 and is fractionated in the bubble tower 15 in a manner well known in the art. The bubble tower contains a number of plates 18, provided with bell caps and reflux lines. The gas and gasoline leave tower 15 by line 19, the gasoline is condensed in condenser 20 and separated from the gas in tank 21. The condensate in the bubble tower may either be removed from the system or returned to the coil or to the accumulator by lines 22, 23, 24 respectively. Valved line 27 serves for adding kerosene or other middle frac-

tion to the charging stock as explained above.

The accumulator and the bubble tower are preferably held under a pressure of about 60 lbs. sq. in. The pressure and the temperature of the soaking drum are chosen according to the composition of the charging stock in line 26 and the conversion in the soaking drum in such a manner that under the rate of heat pick-up in coil 1 the stock remains constantly in the homogeneous state, both in coil 1 and in soaking drum 4. Although this temperature and pressure can be calculated with good accuracy on the basis of theories relating to cracking and heat transfer, I usually prefer to determine them by means of experiments. For this purpose I take a sample of the charging stock (which, of course, will differ in composition from the fresh feed) and subject it to heating in a thick-walled glass tube heated by electrical means. The stock in the tube is held under the hydrostatic pressure of a mercury column and it can be ascertained by visual observation whether the stock is in the homogeneous phase or separated into liquid and vapor phases. The rate of heating can be regulated so as to imitate the corresponding rate in cracking coil 1 and the sample is held under the specified conditions of pressure and temperature as long as the corresponding charge is held in the soaking drum when operating on the large scale.

In practice, where the pressure and feed rate are largely predetermined, it is convenient to control the conditions for homogeneous cracking by the amount and composition of the cycle stock returned for cracking. It is not generally desirable to obtain maximum conversion of the oil in a single heating for two reasons; (1) the pressure for homogeneous cracking increases rapidly with every percent increase in conversion and (2) the gasoline cracks as well as the stock until a point is reached where the gasoline cracks as fast as formed and finally faster. To overcome these two disadvantages I choose to crack to a predetermined conversion and then separate the gasoline and gas, middle fraction and tar by fractionation according to known methods. The middle fraction is returned for further cracking. This middle fraction is more refractory than fresh gas oil. When it is mixed with the fresh feed it has two effects (1) reduces the rate of cracking which reduces the pressure required for homogeneous cracking and (2) it increases the solubility of light and heavy constituents from cracking again with the result that lower pressure is required for homogeneous state.

The following examples will illustrate the operation of my process and the yields obtained:

A feed stock of 31° A. P. I. consisting of 50% cycle stock and 50% fresh gas oil is fed at a pressure of 900 lbs. per sq. in. on the soaking drum of 6'x40' and at a rate of 12,800 gals./hr. This oil leaves the heating coils at 885° F. with a gasoline conversion of 8.12% and leaves the soaking drum at 850° F. and a conversion of 28%, 400° F. end point gasoline on the total feed, corresponding to 56% gasoline yield on the fresh gas oil. The gas yield was 5.8% but only traces of coke were formed. What coke was formed was that due to starting up the unit and attaining steady state, for the conversion remained uniform thereafter showing no clogging of the unit.

If the same unit is run at the same rate but half of the cycle stock is drawn off for furnace oil, the conversion is not steady and coke forms

in the tubes and reaction chamber because the homogeneous state is not realized.

The following example is one of cracking in the homogeneous state under very high pressure and without recycling. A 31.7 A. P. I. Midcontinent gas oil with a feed rate of 13,070 gal. per hour and a pump pressure of 2,460 pounds and an outlet pressure of 2000 pounds leaves the coil at 850° and 13% conversion to 400 E. P. gasoline and leaves the reaction drum as homogeneous gas at 840° F. and 39% conversion to 400 E. P. gasoline, 6.5% gas and 54.5% middle fraction and tar.

When operating at higher temperatures the rate of cracking increases fast and correspondingly the time necessary to obtain a certain degree of decomposition decreases. In such a case the soaking drum can be made considerably smaller or entirely dispensed with and line 3 connected directly to the tar separator 6; the whole cracking being done in cracking coil 1. In order to insure the separation of the tar, cold feed, such as crude oil, gas oil, etc. may be introduced into the hot cracked product just before it is discharged into the tar separator. The cooling thus obtained will precipitate out the tar which must be removed from the system if excessive coke formation is to be avoided.

I am aware that, since early dates in the art of the cracking, it has been proposed to crack in the liquid phase, that is, to hold such a high pressure in conjunction with a low temperature of cracking that the charging stock is in the liquid state during the heating and soaking periods. I therefore do not claim such a process. But it has not been recognized until the present invention that a petroleum oil can be heated and cracked under such conditions that the oil is above the critical range or in the gaseous state at the end of the cracking period and yet at no time during the heating and soaking periods does it separate into a liquid and a vapor phase. This, and the methods adopted to realize this condition, are the essential features of the present invention.

Some modifications of my process have been discussed above. Various other modifications can be made without departing from the spirit of this invention. Furthermore, I do not wish to be limited by any theory or specific data given in way of illustration, but only by the appended claims in which I intend to claim all inherent novelty of my process.

I claim:

1. The process of cracking which comprises passing liquid hydrocarbon oil in a continuous stream through a heating zone of narrow cross section into an enlarged cracking zone, maintaining the oil at cracking temperature in the cracking zone for a time sufficient to obtain the desired conversion into cracked products, regulating the cracking temperature and the pressure in the cracking zone so that the oil therein is in a homogeneous gaseous state, maintaining a pressure in the heating zone equal to that in the cracking zone plus the frictional pressure drop due to the passage of the oil through the heating zone, maintaining the pressure in the cracking zone and the rate of heating in the heating zone sufficiently high to insure a homogeneous state of the oil at any cross section in both the heating and the cracking zones, and separating the cracked oil into desirable fractions.

2. The process according to claim 1, in which the hydrocarbon oil to be cracked consists of gas oil or other heavy oil, and a lighter oil is added to the oil before the heating zone to reduce the pressure to be maintained in the heating and cracking zones.

3. The process according to claim 1, in which the hydrocarbon oil to be cracked consists of gas oil or other heavy oil; and kerosene or heavy naphtha is added to the oil before the heating zone to reduce the pressure to be maintained in the heating and cracking zones.

EDWARD B. PECK.

Critical Temperatures and Oil Cracking^{1,2}

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OIL-CRACKING processes have been generally classified by petroleum technologists as liquid- and vapor-phase cracking. The extensive use of these terms in the literature of the industry, especially in patent specifications and drawings, makes it imperative that some dependable standard be established to differentiate between the two methods.

Since the fundamental work on critical phenomena, by Cagniard de la Tour³ more than one hundred years ago, the temperature of change between the liquid and vapor states when a liquid, either pure or a binary mixture, is heated under pressure has been recognized as the critical temperature. There seemed to be no reason why this distinction could not likewise be applied to more complex liquid mixtures such as gas oils and other cracking stocks, and that a scientific basis for differentiating between liquid- and vapor-phase cracking processes might be established.

With this purpose in view an investigation was carried out to determine the critical temperatures of these complex mixtures, including both well- and shale-petroleum distillates. It was found that these oils have definite critical temperatures in just the same way as the simpler binary mixtures of organic compounds which have been previously reported in the literature. In addition it was learned that these critical temperatures may be calculated from the

average boiling points, in turn obtained from the ordinary standard analysis (A. S. T. M. method), by the following equation:

$$t_c = 1.054 + 160 \quad (1)$$

This also represents the relationship between the boiling points and critical temperatures of normal, straight-chain aliphatic hydrocarbons. Further, this work shows that this equation holds for mixtures of straight- or branched-chain saturated or unsaturated aliphatic hydrocarbons, and for naphthenes, but not for aromatic compounds. The equation was derived from the boiling point-critical temperature graph for the straight-chain aliphatic compounds, t_c being the critical temperature in degrees Centigrade, and t_b the average boiling point. If Fahrenheit temperatures are used, 286 is substituted for the figure 160. Future workers, by the use of this equation, which checks the observed critical temperatures quite accurately for well-petroleum and shale-petroleum oils, can avoid an experimental determination of the critical point.

The experimental data reported in this paper cover distillates from five widely separated fields in this country, varying in boiling point from that of petroleum ether to that of gas oil. Zeitfuchs's experimental values⁴ listed in Table I check with the writers' equation. Furthermore, the standard A. S. T. M. analyses reported herein were made by three different persons. It would thus seem that the equation was applicable under a wide variety of laboratory conditions and that the method was essentially free from factors of personal error.

¹ Presented by title before the Division of Petroleum Chemistry at the 73rd Meeting of the American Chemical Society, Richmond, Va., April 11 to 16, 1927. Revised paper received July 6, 1928.

² This paper is part of the work presented by the junior author for the degree of doctor of philosophy in the Department of Chemical Engineering, Columbia University.

³ *Ann. chim. phys.*, [2] 21, 121 (1821).

⁴ *Ind. Eng. Chem.*, 18, 79 (1926).

Table I—Calculated Values from Work of Zeitfuchs on California Petroleum Oils

Oil	GRAVITY ° A. P. I.	AV. BOILING POINT ° C.	CRITICAL TEMPERATURE	
			Obed. ° C.	Calcd. ° C.
Petroleum ether	80.9	32	211	216
Gasoline	53.9	136	308	303
Naphtha	48.2	156	348	324
W. W. distillate	40.8	203	376	372
Gas oil	27.8	286	459	461

Critical Temperatures of Cracking Oils

The work also revealed the fact that the critical temperatures of the oils used as cracking stocks, especially those containing lighter distillates, as would be the case in actual operation, were lower than the temperatures used in some of the more important, so-called liquid-phase processes such as the Cross and the "tube and tank." In plant operation of these the average temperature of the oil leaving the heating tubes is 454° C. (850° F.). The critical temperature of the charging stock is generally less than this and is lowered as cracking occurs, owing to the formation of non-condensable gas and lighter fractions. This is well illustrated by the data in Table II, which were calculated from distillation analyses of the charging stock and of oil leaving the heating tubes in a cracking unit of the Cross type.

It will be observed that the cracking occurring in the tubes produces a sufficient quantity of gas and lighter oil fractions to lower the critical temperature of the charging stock 20° C. (36° F.). This value is further decreased as the cracking proceeds in the reaction chamber. In the "tube and tank" process the percentage of the cracking taking place in the tubes is even larger than in the Cross process.

Further confirmation of this lowering of the critical temperature is furnished by the experimental work with mixtures of gas oil and gasoline. (Table VI) Such hydrocarbon mixtures apparently obey the rule of Straus and Pawlewski,⁶ which states that the critical temperature of the mixture is proportional to the volume per cent of the components. This empirical relationship is discussed elsewhere in this paper.

Table II—Average Critical Temperature for Different Distillates

Stock	Obed. ° C.	SAME WITH 30% BY VOL. OF GASOLINE	CROSS PLANT DATA			
			Charging stock		Oil at end of tubes	
			° C.	° F.	° C.	° F.
Kerosene	405	376	444	831	424	795
Mineral seal or "300"	458	413				
Gas oil	475	435				

The temperature dividing lines listed in Table II were calculated by this rule. They show the approximate limit of the operating temperature above which the oil cannot exist as a liquid. These average critical temperatures are given for different charging stocks and are based upon the above plant and laboratory evidence. Accurate figures may be calculated for any particular oil from the distillation analysis by the above equation.

Critical Temperature of Binary Mixtures

Critical temperatures of pure compounds, of binary mixtures, and also of solutions have been generally recognised

⁶ J. Russ. Phys.-Chem. Soc., 12, 307 (1890).

as definite dividing lines between liquid and vapor states, although certain workers⁶ have failed recently to see a connection between this and the existence of a critical temperature for petroleum distillates. Landolt and Börnstein⁷ list some thirty-nine binary mixtures for which critical data have been reported. Hartman⁸ has published an elaborate treatise on the phase relations involved, and Straus and Pawlewski⁶ have proposed a simple volume rule with which to calculate the critical temperatures of the mixtures from those of the components. Forty-three per cent of the binary mixtures listed in Landolt and Börnstein obey this rule. Examples are air for gases and mixtures of ethyl ether and benzene for liquids. No work has been done with members of the same homologous series, but the present writers' work with gas oil, gasoline, and kerosene shows that such mixtures of these hydrocarbons obey this rule.

Very little work has been published for mixtures of more than two components. Zeitfuchs⁴ has recently made some measurements on California petroleum oils, and Guido⁹ has studied the effect of composition on the critical temperature of lemon oil.

Of interest to the petroleum technologist is the compilation by Wilson and Bahlke¹⁰ of critical data for saturated, normal aliphatic hydrocarbons.

It seems unreasonable to suppose that these more complex hydrocarbon mix-

tures (gas oils, kerosenes, and gasolines) should differ materially in their behavior from the above binary mixtures. Phase rule relations demand that there be one definite temperature at which the mixture is homogeneous. Further, the experimental work of the writers has proved beyond question that there is a definite temperature at which the liquid phase vanishes.

Experimental Procedure

The determinations were made in sealed tubes of Pyrex glass 10 to 12 cm. long. These were heated in an electric furnace like the one described by Zeitfuchs,⁴ with sufficient variable resistance in the circuit to maintain a constant temperature at any point over the range 250° to 500° C. A furnace in which the tubes could be placed horizontally was not found satisfactory, since the meniscus could not be readily seen. The glass tubes should have a bore large enough (1 to 3 mm.) that the meniscus may be readily observed, and a side wall at least as thick as the inside diameter to avoid any danger of breakage at the high pressure. This pressure is for the gasolines near 400 pounds per square inch (28.2 kg. per sq. cm.) in the vicinity of the critical point. It decreases as the boiling point of the oil is increased. The tubes are preferably sealed by using an oxy-gas or oxy-acetylene flame while the filled end of the tube is immersed in an ice and salt mixture.

The critical temperature, the point at which the meniscus

⁴ Kleinschmidt, Gasoline Products Co. vs. American Refining Co., U. S. District Delaware; Equity 571, p. 348. Little, *Ibid.*, p. 370 (1926). Wilson, U. S. vs. Standard Oil Co. (Ind.), et al., Northern District Illinois, Equity 4131, p. 2731 (1926).

⁷ Tabellen, Vol. I (1923).

⁸ J. Phys. Chem., 5, 425 (1901).

⁹ Giorn. chim. ind. applicata, 4, 8 (1921).

¹⁰ Ind. Eng. Chem., 16, 115 (1924).

disappeared on heating and appeared on cooling, was measured with a platinum, platinum-rhodium thermocouple in conjunction with a Leeds and Northrup portable potentiometer. The glass furnace is shown in Figure 1.

Accuracy of Measurement

The accuracy of the measurement depends upon accurate temperature-measuring instruments, elimination of lag between oil and furnace temperature, provision for having the contents of the tube homogeneous at the critical point, and correct observation of the critical point.

Correct temperature measurement was insured by using the thermocouple above mentioned. The set-up had been recently standardized and was accurate to $\pm 2^\circ \text{C}$.

Temperature lag between the oil in the thick-walled glass tube and the air of the furnace might introduce considerable error. This would be most easily eliminated in ordinary work by maintenance of constant temperature for some time in the vicinity of the critical point. However, appreciable cracking occurs with these materials if maintained at a high temperature for 10 to 15 minutes. This changes the composition of the liquid and introduces an error into the measurement. To exclude this, experiments were first run with an equimolar mixture of sodium and potassium nitrates, which was inserted in the furnace under conditions similar to those under which the oil was inserted. It was found that a rate of about 5°C . per minute near the critical point gave no appreciable lag. No cracking was evident under these conditions except with the mineral seal and gas oils having critical temperatures near 460° and 480°C ., respectively. To determine the magnitude of the error introduced by this cracking, the critical temperature of a Bradford, Pa., gas oil was ascertained as in the previous runs; the tube was then allowed to cool and a second determination made using the same tube. In like manner a third value of the critical temperature was obtained. If cracking occurred during these runs, successive values should be lower than the previous one, and the amount of this lowering would depend upon the quantity of the lighter fractions present, which is a measure of the amount of cracking. The extent of this cracking is governed by the time at the high temperatures—in this case the time that the tube was kept above 375°C ., below which the amount of cracking would not be appreciable as shown by recent work of Lealie and Potthoff.¹¹ The first time noted in Table III was only that required to heat the tube from 375°C . to the critical point, or 9 minutes. The 7 and 8 minutes included both the time of cooling from the first observed critical point to below a temperature at which any appreciable cracking occurs and also the time of reheating to determine the critical point of the now partially cracked oil.

Table III—Effect of Cracking on Critical Temperature Measurement (Gas oil, Bradford, Pa., field)

HEATING	OBSD. CRITICAL TEMPERATURE ° C.	TIME OF CRACKING Minutes
First	475	9
Second	470	8
Third	463	7

From each of these determinations the lowering of the critical temperature of the oil in the tube per minute of cracking may be roughly evaluated. This effect averages near 7°C . for 9 minutes of cracking. It is accordingly apparent that we have here a source of error which gives, with materials such as gas oils, which crack at this temperature, an observed critical temperature only a few degrees lower than the true value of the starting material.

Error due to incorrect observation of the critical point was avoided by determining the critical temperature of carefully purified bromobenzene. The value found was 393°C .

¹¹ *Ind. Eng. Chem.*, 18, 776 (1926).

as compared with 397°C . reported in the literature. This lower value may be due to the slight decomposition which plainly occurs when bromobenzene is heated in a sealed tube to the critical point.

Different values are obtained when different amounts of oil are used in the tube, as shown by the data in Table IV. The ratios refer to the volume of the tube compared with the volume of the oil at room temperature. A high ratio gives a high result, which agrees with work recently published by Zeitfuchs¹² for California petroleum oils. The error may be as large as 40°C .

This variation with binary mixtures led early workers to doubt the existence of a definite critical point, but the experiments of Young,¹³ Ramsay,¹⁴ and Villard¹⁵ clearly showed that it was due to differences in the composition of the liquid and vapor phases.

This error, due to not having the contents of the tube homogeneous at the critical point, was avoided in this work by filling the tubes so that, allowing for expansion, they would be practically full near the critical point. It was impossible to remove all error in this way, as the liquid must always be at least a short distance from the top in order to observe the meniscus. However, this error is not more than 4°C . if a tube-liquid ratio of 1.9 is used—that is, with the tube about one-half full—as the expansion ratio between the liquid at the critical point and the liquid at room temperature is near 1.7. A difference in ratio should give a result about 4°C . too high based on interpolation from the data in Table IV.

Table IV—Effect of Tube-Liquid Ratio

OIL	RATIO $V_2:V_1$	OBSERVED CRITICAL TEMPERATURE ° C.
Gasoline:		
A	4.0	336
A	2.7	309
A	1.9	288
B	3.0	305
B	2.3	286
B	1.9	282
Kerosene:		
C	4.0	420
C	2.8	408
C	2.0	392

This difficulty with binary mixtures has been overcome by former workers by rotating the tube in the heating medium. According to Nernst,¹⁶ very well defined values can be obtained in this way, and Centnerswer and Zoppi¹⁷ report measurements accurate to 0.1°C . Both references are to binary mixtures. Experimental difficulties due to the cracking of the oil at the high temperature made it impracticable to use such a set-up in this work.

The over-all accuracy of these experiments is no doubt well within 10°C . limits. The maximum difference between

¹² *J. Chem. Soc. (London)*, 717, 447 (1907).

¹³ *Z. physik. Chem.*, 14, 486 (1894).

¹⁴ *Ann. chim. phys.*, [7] 19, 387 (1897).

¹⁵ "Theoretical Chemistry," 8th to 10th German editions, revised by Codd, 1923, p. 74, Macmillan and Co., Ltd.

¹⁶ *Z. physik. Chem.*, 84, 689 (1905).



Figure 1—Furnace for Critical Temperature Measurement

the readings obtained on heating and cooling was around 0.06 millivolt or approximately 6° C. and the average deviation was 0.03 millivolt or 3° C. The error due to not having the tube completely full makes the measurement too high by about 4° C. Adding to this a maximum error in temperature reading of 2° C. makes the total possible error nearly 10° C. The agreement between the observed and calculated values of the critical temperature is well within the requirements, as the differences may be due to errors in the experimental work.

General Discussion

The empirical equation (1) developed in the course of this study expresses the critical temperatures of the oils as a straight-line function of their boiling points. These are calculated by averaging the initial temperatures with those recorded for each of the 10-cc. cuts in the standard A. S. T. M. distillation. The temperature corresponding to 100 cc. of distillate was obtained by extrapolation. An example of this method of calculation is given below:

Bradford, Pa., Gasoline; Gravity 61.3° A. P. I.

DISTILLATION ANALYSIS			
Distilled	Temp.	Distilled	Temp.
Cc.	° C.	Cc.	° C.
First drop	46	60	137
10	78	70	150
20	93	80	166
30	105	90	186
40	116	100 (est.)	228
50	127		

$$\text{Av. boiling point} = \frac{\sum t}{n} = \frac{1432}{11} = 130^{\circ} \text{C.}$$

Then, by equation (1)

$$t_c = 1.05t_b + 160 = 1.05 \times 130^{\circ} + 160 = 296^{\circ} \text{C.}$$

Observed critical temperature = 298° C.

This method does not, of course, give the true average boiling point of the oil if considered from the ideal case in which the distillation curve is a straight line. It has been used in this work because of its wide acceptance in previous literature, and it has the further advantage that it makes use of an established method of analysis, the A. S. T. M. distillation.

As noted above, this equation was derived from a consideration of the boiling points and critical temperatures of normal, straight-chain aliphatic hydrocarbons. It may also be used to calculate critical temperatures for unsaturated compounds, of which some typical ones are listed in Table V.

Table V—Critical Temperatures of Unsaturated and Aromatic Hydrocarbons

HYDROCARBON	BOILING POINT ° C.	CRITICAL TEMPERATURE	
		Obsd. ° C.	Calcd. ° C.
UNSATURATED			
Amylene	40	201.2	202
Isomylene	36	191.6	197
Isobutylene	-5	150.7	154
Diallyl	55.5	234.4	232
Diisopropyl	57	227.3	220
Octylene	124.6	304.8	290
AROMATIC			
Benzene	80.1	288.5	(1) 244 (2) 288
Toluene	110.7	320.6	276 319
o-Xylene	142	358.3	309 350
m-Xylene	139	345.6	305 347
p-Xylene	137	344.4	302 345
Hexamethylene	81	290	244 290

Aromatic compounds, some of which are listed in this table, do not obey this rule. The relationship in this case may be expressed by the following equation using Centigrade temperatures and the same symbols as before:

$$t_c = t_b + 208 \quad (2)$$

Its use is illustrated by the calculated values in the column with the heading (2) in Table V.

The presence of these aromatic compounds in the Vinton, La., and shale distillates is indicated by the high gravity-

boiling point ratio as commented upon by Rittman, Dutton, and Dean.¹⁷ In support of this it was found that the critical temperatures of these oils listed in Table VI are intermediate between calculated values by the above equations. In other words, the last equation above should give the true critical temperature of a mixed distillate only if the oil contained 100 per cent of aromatic compounds. The other equation should hold if no aromatics were present. This critical temperature work may thus be used to indicate the chemical nature of the substances present in the oil.

Table VI—Observed and Calculated Critical Temperatures

OIL	ORIGIN OF CRUDE	GRAVITY ° A. P. I.	AV. BOILING POINT ° C.	CRITICAL TEMPERATURE	
				Obsd. ° C.	Calcd. ° C.
Gasoline	Utah shale	47.4	179	358	348
Kerosene	Utah shale	34.0	240	433	412
Gas oil	Utah shale	26.6	...	438	...
Gasoline No. 1 ^b	New York City	54.5	137	301	304
Gasoline No. 2 ^b	New York City	59.5	135	298	302
Gasoline No. 3 ^b	New York City	60.6	131	302	298
Gasoline No. 4 ^b	New York City	58.0	137	307	304
Gasoline	Burbank, Okla.	57.2	138	310	305
Gasoline	Bradford, Pa.	61.3	130	298	296
Gasoline	Pioneer, Texas	56.3	140	307	307
Naphtha	Vinton, La.	50.3	140	322	307
"Turpentine sub-					
stitutes"	Vinton, La.	39.4	182	361	351
Kerosene	Burbank	42.1	232	407	405
Kerosene	Bradford	45.3	234	446	406
Kerosene	Pioneer	42.9	222	407	406
Kerosene	Vinton	32.5	213	400	384
"200" oil	Burbank	37.0	283	453	458
"200" oil	Bradford	40.5	284	457	458
"200" oil	Pioneer	38.1	284	455	458
Gas oil	Bradford	38.2	311	478	487
Gas oil	Vinton	28.0	266	470	439
Transformer oil	Vinton	24.0	...	463	...

^a No distillation analysis.

^b Four typical gasolines on sale in New York City, November, 1926.

Observed and calculated critical temperatures for the different oil distillates are compared in Table VI. The shale-petroleum distillates possess slightly higher critical points than the corresponding well-petroleum materials, perhaps owing to the presence of aromatic compounds. Both classes exhibit very definite transition temperatures.

The critical temperatures of different percentage-by-volume mixtures of gas oil and gasoline are shown in Table VII. The calculated values are based on the rule of Straus and Pawlewski.⁸ Thus for the mixture containing 10 per cent by volume of gasoline having an observed critical temperature of 298° C., the critical temperature is $0.1 \times 298^{\circ} + 0.9 \times 478^{\circ} = 459^{\circ} \text{C.}$ The observed value was 468° C.

Table VII—Critical Temperatures of Mixtures of Gasoline and Gas Oil

OIL	CRITICAL TEMPERATURE	
	Obsd. ° C.	Calcd. ° C.
Bradford gas oil	478	487
Bradford gas oil containing 10% by volume of gasoline	468	459
Same, 20% gasoline	457	443
Same, 33% gasoline	425	418
Burbank "200" oil and Burbank gasoline, 50% by volume	380	381

Effect of Asphaltic Materials

Finally, the question arose as to whether asphaltic materials soluble in the oil to give a liquid, similar to a charging stock, remained in solution above the critical point. Work with such solutions showed no precipitate even when the liquid was kept for a long time above the critical temperature proving that the asphalt was soluble in the highly compressed vapor. This agrees with work¹⁸ previously reported in the literature for solutions of various non-volatile solutes in organic solvents.

Acknowledgment

The authors wish to acknowledge the kindness of W. F. Coover and F. E. Brown in placing the facilities of the Chemistry Laboratory, Iowa State College, Ames, Ia., at their disposal during the summer of 1926.

¹⁷ Bur. Mines, Bull. 114, p. 74.

¹⁸ Chem. News, 41, 103 (1890).

FROM DEFENDANT'S EXHIBIT 1

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Paper No. 7**October 7, 1939****EXAMINER'S STATEMENT.**

This is an appeal from the Examiner's action in finally rejecting claims 1 and 2, the only claims in the case.

1. The process for conversion of higher boiling petroleum oils to lower boiling oils which comprises heating the higher boiling oil to vaporize it and thereafter to crack it, maintaining a pressure exceeding the critical pressure on the oil through the point of vaporization and heating the oil prior to vaporization at a rate high enough to prevent substantial decomposition prior to vaporization.

2. The process for conversion of higher boiling petroleum oils to lower boiling oils which comprises heating the higher boiling oil to its critical temperature and thereafter to crack it, maintaining a pressure exceeding the critical pressure on the oil through the point at which it attains its critical temperature and heating the oil prior to this point at a rate high enough to prevent substantial decomposition prior to this point.

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References used in the rejection:

Gard	1,914,914	June 20, 1933
Peck	1,933,507	Oct. 31, 1933
McKee	"Critical Temp. and Oil Cracking"; Ind. and Eng. Chem.; Vol. 20, No. 11; Nov. 1928; pp. 1169-1172.	

DESCRIPTION OF THE PROCESS.

The process involves the cracking of a high boiling petroleum oil to make low boiling oil of the nature of gasoline.

The oil, entering at 1 is heated in 3 under a pressure above the critical pressure and at a rate rapid enough to prevent substantial decomposition before reaching point 9. The heating is carried out in 3 in the liquid phase, reaching the critical temperature of the oil at 9 at which point it changes to the vapor phase.

After point 9, the oil vapors are cracked in the coil 4 and the products are quenched after valve 5.

REASONS FOR THE REJECTION.

Claims 1 and 2 are deemed met by Gard who discloses gas oil heated in 11 in the liquid phase under high pressure of 1000-2000 lbs. per sq. in. (the applicant uses 800-1200 lbs. per sq. in.). The Gard pressure is therefore higher than the critical pressure if applicant's figures are correct. This pressure of Gard is maintained through the point of vaporization because Gard reaches the critical temperature just before the venturi 14 (pages 3, 209 lines 119-121). After the venturi 14, the vapors are cracked in the vapor phase in cracking coil 17. Gard gives the critical temperature of his oil to be 862° F. (example on page 3, last paragraph) checking with McKee and Parker in Table 1 on page 1170 (gas oil, about 460° C. or 860° F.).

The only issue between applicant and Examiner is whether Gard heats the oil prior to vaporization at a rate high enough to prevent "substantial" decomposition. It is the Examiner's belief that the recitation "substantial" in claims 1 and 2 (last two lines) was inserted to permit an *incidental* cracking or else the claims would have read "at a rate high enough to prevent decomposition prior to vaporization."

Gard's rate of heating prior to vaporization is *rapid*. Note claim 8 and page 3, lines 83-84. Moreover, while in the liquid phase in the coil 11 Gard does not wish to crack

the oil. He states on page 1, lines 93-97 that only *incidental* cracking occurs before the oil reaches the critical temperature when it flashes to the vapor phase. He states on page 1, lines 31-34 that the oil is heated in the liquid phase "to" the cracking temperature and then expands the oil in vapor phase coil (17). In every case, Gard's intention seems clear to operate 11 as a liquid phase *heating* coil and 17 as a vapor phase *cracking* coil; and if any unavoidable cracking does occur in 11, it is merely incidental and very small in amount. Obviously he heats in 11 at a rate to prevent "substantial" decomposition as stated in claims 1 and 2.

As is true of all cracking processes, Gard is certainly operating to prevent carbon formation in the tubes. Since his steps are the same as recited in the claims, he is entitled to all the benefits flowing from his procedure (as prevention of pitch formation).

While Gard is considered the most pertinent reference, attention is also called to Peck who operates a coil and drum unit to heat oil at a rapid rate in the liquid phase and maintaining so high a pressure that when the critical temperature is reached, the oil changes instantly to the vapor phase, called by Peck "homogenous cracking" meaning no mixed liquid-vapor phase at any time. Peck attempts to avoid carbon formation in this way (page 2, lines 30-35). His pressure of operation is 900-2460 lbs. per sq. in. The rate of heating is *rapid* (page 2, lines 133-135 and claim 1).

Peck does not indicate in a positive manner that no "substantial" decomposition occurs during the liquid phase operation but states that the heating up can be effected in so short a time that when the critical temperature is reached (850° F.), the cracking is below 25% gasoline, page 2, lines 137-140. The example on page 3, lines 133 and following give 8.12% conversion to gasoline when the oil reaches 885° F. When we consider McKee and

Parker's table, 1, of gas oil having a critical temperature of 860° F. (460° C.), when Peck reaches only 211 860° F. (the point where the oil changes from liquid to vapor) it is obvious that much less than 8.12% conversion will be present since the velocity of cracking is cut in half with each drop of 18° in the Fahrenheit scale.

For the reasons given above, claims 1 and 2 are also believed met by Peck.

In view of the art, it is believed that the rejection should be sustained.

Respectfully,

Examiner, Div. 31.

BRIEF FOR APPELLANT

IN THE
United States Court of Appeals
FOR THE DISTRICT OF COLUMBIA.

UNITED STATES
COURT OF APPEALS FOR THE
DISTRICT OF COLUMBIA

FILED SEP 11 1942

—•—
No. 8310.
—•—

Joseph W. Starnes

CLERK

SINCLAIR REFINING COMPANY,

Appellant,

v.

CONWAY P. COE, Commissioner of Patents,

Appellee.

Appeal from the District Court of the United States
for the District of Columbia

Filed June 4, 1942

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IN THE
United States Court of Appeals
FOR THE DISTRICT OF COLUMBIA

No. 8310

SINCLAIR REFINING COMPANY,

Appellant,

v.

CONWAY P. COE, Commissioner of Patents,

Appellee.

BRIEF FOR APPELLANT

Jurisdictional Statement

The appellant filed its complaint in the District Court under Section 4915, R. S. (35 U. S. C., Sec. 63) against the appellee Conway P. Coe, as Commissioner of Patents, to obtain a decree that the appellant was entitled, as the assignee of Reading B. Smith, to have a patent issued to it on Reading B. Smith application Serial No. 194,776, filed March 9, 1938 (Appellant's App. 1-3). Appellee's answer (Appellant's App. 4-5) contended that the claims for which appellant seeks a patent were unpatentable over certain prior art patents and publications identified in the answer.

The Court below (Justice McGuire) after hearing the witness for appellant entered a final decree on May 6, 1942 dismissing the complaint (Appellant's App. 8-9). No opinion was rendered by the Court below, but findings and conclusions drafted by the solicitor for the Patent Office were entered by the Court (Appellant's App. 7-8).

Appellant filed its notice of appeal to this Court on June 3, 1942 (Appellant's App. 9). This Court has jurisdiction of this appeal under the act of February 9, 1893, c. 74, 27 Stat. 435, as amended and as incorporated in the District of Columbia Code, 1940 Edition, Title 17, Sec. 101.

Statement of Case

The Smith invention for which appellant seeks a patent is a new and improved oil cracking process, i. e., it is a process for converting higher boiling oils such as gas oil and kerosene into lower boiling oils such as gasoline. This new and improved process is defined in the two claims recited in the complaint (Appellant's App. 2) and reproduced herewith for convenience:

1. The process for conversion of higher boiling petroleum oils to lower boiling oils which comprises heating the higher boiling oil to vaporize it and thereafter to crack it, maintaining a pressure exceeding the critical pressure on the oil through the point of vaporization and heating the oil prior to vaporization at a rate high enough to prevent substantial decomposition prior to vaporization.

2. The process for conversion of higher boiling petroleum oils to lower boiling oils which comprises heating the higher boiling oil to its critical temperature and thereafter to crack it, maintaining a pressure exceeding the critical pressure on the oil through the point at which it attains its critical temperature and heating the oil prior to this point at a rate high enough to prevent substantial decomposition prior to this point.

The characteristic feature of novelty in the Smith process resides in the manner in which the oil is heated up to a point at which it vaporizes. In the Smith process the higher boiling oil to be cracked is heated until vaporization has

occurred (a) under a pressure "exceeding the critical pressure", and (b) at an *extremely* rapid heating rate, defined in the involved claims as "a rate high enough to prevent substantial decomposition". Smith discovered that when this procedure is followed, the chemical reaction which occurs when the oil vapors are further heated is markedly different in character from that which occurs in any oil cracking process heretofore known in that it produces lower boiling oils *without simultaneously forming tar-like material as a by-product* (Appellant's App. 38-40). This result is revolutionary in character. It had never been accomplished before and it was believed to be unattainable. It represented a real advance in the art.

The Smith application here involved is reproduced in appellant's appendix at pages 66-71, and the final rejection by the Examiner and the decision of the Board of Appeals with respect thereto appear, respectively, at pages 73 and 74-76. Consideration of several statements that appear in the decision of the Patent Office Board of Appeals, to which specific attention will later be directed, suggested that a misconception existed as to certain technical matters that are essential to a clear understanding of both the identity of the invention for which appellant seeks a patent and its relationship to the prior art. Accordingly, at the trial of this case before the District Court, Reading B. Smith, whose application is here involved and who is an engineer of some thirteen years experience in the development of oil distilling and oil refining units involving cracking (Appellant's App. 16), was called as a witness to explain those material technical matters with respect to which confusion appeared to exist. Smith also described in detail certain experimental operations embodying his invention and he explained more fully the relationship of his invention to the prior art; the prior practical art on the one hand and the prior paper art cited by the Examiner on the other. Smith's testimony in its entirety is reproduced in appellants appendix at pages 15-65.

The Cracking Reaction

When a high boiling oil is heated and its temperature is thereby progressively raised, it begins to decompose chemically when a temperature of approximately 700° F. is attained. At this temperature the rate of decomposition is relatively slow. But as the temperature is further raised the rate of decomposition increases rapidly. This chemical decomposition is known as the cracking reaction (Appellant's App. 48-49). One of the results of the cracking reaction is the production of an oil which, under normal conditions, will boil at a lower temperature than that at which the original oil will boil before it has been subjected to the cracking reaction. Gasoline, a low boiling oil, is the primary and desired product of the cracking reaction in practically all commercial cracking processes.

However, an undesirable by-product of the cracking reaction in all cracking processes heretofore known, has been a tar-like or pitch-like material (Appellant's App. 40). This tar-like or pitch-like material is a by-product of little value as compared to gasoline (Appellant's App. 56). Aside from its low value, this tar-like or pitch-like by-product has the undesirable characteristic of decomposing still further if it is maintained at a cracking temperature for a prolonged period of time. This further decomposition is accompanied by the formation of carbon or coke.

In the earlier forms of industrial oil cracking processes the production of carbon or coke was extensive (Appellant's App. 57). Its formation and decomposition within the cracking apparatus was the bane of the industry. In some of the early cracking processes carbon incrustations formed on the surfaces through which heat was transmitted to the oil. This resulted in dangerous overheating of the heat transmitting surfaces and frequently caused disastrous explosions and fires. Even in certain forms of processes where the carbon was deposited in a portion of the cracking system to which no external heat was applied, the continued accumulation of deposited carbon necessitated fre-

quent discontinuance of the cracking process to clean out the deposited material.

It may be well here to state as an abstraction, that the temperature at which an oil begins to crack (i. e., its "cracking" temperature) is far below the "critical" temperature of the oil (Appellant's App. 46, 56). The "critical temperature" of an oil (assuming the absence of decomposition which destroys its identity) is by definition the temperature above which it cannot be maintained in the liquid state no matter how high the prevailing pressure (Appellant's App. 50-51). The "critical pressure" is by definition that pressure which will maintain a substance entirely in the liquid state at all temperatures up to its "critical temperature".

The Prior Practical Art

The witness Smith pointed out that, aside from catalytic cracking processes and low pressure vapor phase cracking processes both of which have been used only to a limited extent and neither of which has any bearing on the Smith process here in question, the oil cracking processes which have been extensively used industrially are classifiable in three general types or groups (Appellant's App. 17). Of course each of these general types has been used in various modified forms. These three types Smith classified as (1) the "bulk pressure distillation" type of process, (2) the "tube and tank" type of process, and (3) the "high-pressure coil cracker" type of process (Appellant's App. 17).

Smith also described the identifying characteristics of each of these three categories. He pointed out that in the "bulk pressure distillation" type of process a large bulk of the oil to be cracked is heated under pressure in a large boiler, tank or vat to which heat is directly applied. The maximum temperature attained in this type of process was relatively low, so that the oil cracked slowly. He testified that the gasoline formed by the cracking reaction in this

type of process distilled off at a rate on the order of only 2% an hour. Naturally with this low distillation rate, the rate of heating was very slow (Appellant's App. 17). The well known and extensively used Burton process was the outstanding example of this type of process. In this bulk pressure distillation type of process, carbon, formed as the result of progressive decomposition, deposited on the heat transmitting surfaces with frequently disastrous results.

The so-called "tube and tank" type of process was developed as one of the first attacks on the carbon problem. Smith testified that this type of process is characterized by the fact that the oil to be cracked is first passed through a heating coil (i. e., a tube) and then into an enlarged externally unheated pressure chamber (i. e. a tank). The oil is maintained under the desired pressure in both the coil and the tank. As the oil flows through the coil it is heated to a temperature high enough to permit maintenance of the desired cracking temperature in the externally unheated chamber by virtue of the heat contained in the entering oil. During its passage through the heating coil the oil is heated at a rate that is quite rapid as compared to the rate of heating employed in the earlier bulk pressure distillation type of process (Appellant's App. 17-18).

In this tube and tank type of process the oil emerges from the heating coil before it has an opportunity to remain at a cracking temperature long enough to permit any considerable amount of carbon formation. The major portion of the cracking occurs in the unheated pressure chamber, or tank (Appellant's App. 17-18). Carbon that is formed by the continued cracking which occurs in the tank settles out and accumulates in the tank, but since the tank is externally unheated this carbon does not deposit on the heat transmitting surfaces so that overheating of the heat transmitting surfaces is avoided. This was a distinct advance over the earlier bulk pressure distillation process. However, the continued accumulation of deposited carbon

in the pressure chamber, or tank, did necessitate frequent discontinuance of the cracking operation to permit removal of the accumulated carbon in processes of this type.

Smith testified that the Dubbs process, the Cross process and the Holmes-Manley process were the three outstanding examples of processes of this type. He cited pages 332 and 333 of the Handbook "Petroleum Asphalt and Natural Gas" by Cross (Appellant's App. 18, 19, 77 and 78) as embodying a conventional illustration of the well known and extensively used Dubbs cracking process; pages 322, 324 and 325 of the same handbook (Appellant's App. 19-21, 79-81) as embodying a conventional illustration of the well known and extensively used Cross process; and Behimer patent No. 1,883,850 (Appellant's App. 21, 22, 84-88) as embodying a conventional illustration of the well known and extensively used Holmes-Manley process.*

Smith further pointed out that while the heating rate in the heating coils of the tube and tank type of process was higher than the heating rates encountered in the bulk distillation type of process (Appellant's App. 17), nevertheless it was conventional practice to shield the heating coil in the tube and tank type of process so as to prevent or limit direct radiation from the flame, and thus limit the heating rate (Appellant's App. 18-22).

In this type of process the temperature maintained in the pressure chamber, where the major portion of the cracking occurs, does not exceed 900° F. and usually approximates 850° F. (Appellant's App. 78, 79 and 87).

The third and most recent type of cracking process that has gone into extensive commercial use was identified by Smith as the "high-pressure coil cracker" type of process or as the "Winkler-Koch" type of process; the Winkler-Koch process being recognized as the outstanding example of this type of process (Appellant's App. 17). The Win-

*The application upon which this Behimer patent was granted was originally filed in the name of Holmes, Manley and Behimer (See footnote 3 on page 99 of appellant's appendix).

kler-Koch process, although itself unpatented, has been the subject of extensive patent litigation; one such instance being the suit of Texas Co. v. Anderson-Prichard Refining Corporation wherein a Winkler-Koch installation was charged to involve infringement of Behimer patent No. 1,883,850.

In 1936, the period immediately preceding Smith's discovery of the process involved in the present controversy, the appellant herein was an operator of the Winkler-Koch type of cracking process. During this period Smith was in direct contact with the operations of appellant's Winkler-Koch still. Smith described the Winkler-Koch type of process from his own knowledge (Appellant's App. 23-26) and also testified that the drawing comprising Plaintiff's Exhibit 5 (Appellant's App. 95) correctly illustrated the Winkler-Koch type of process, and that the description of the Winkler-Koch process contained in that part of the decision of the Court of Appeals in the Texas v. Anderson-Prichard case appearing in appellant's appendix at pages 100-102 embodies a correct description of the Winkler-Koch operation as Smith himself knew it.*

*The many strenuously contested patent controversies with respect to the Winkler-Koch process (Appellant's App. 33-35) have no direct bearing upon any issue involved in the present case. A copy of the drawing constituting Plaintiff's Exhibit 135 in the Texas v. Anderson-Prichard case was selected for the purpose of illustrating the "Winkler-Koch" or "high-pressure coil cracker" type of process and offered as Plaintiff's Exhibit 5 in the present case, simply because it embodied a convenient and accurate illustration of that type of process. Likewise, those parts of the opinions of the District Court and of the Court of Appeals in the Texas v. Anderson-Prichard case that have been included in appellant's appendix in the present case, have been made of record simply because they incorporate accurate, concise and apt descriptions of the cracking portion of the system in the Winkler-Koch type of process. There is no discrepancy between Smith's description of the Winkler-Koch type of process and the descriptions given in the opinions in the Texas v. Anderson-Prichard case. In the many and strenuously contested patent suits involving the Winkler-Koch type of process, there never has been any serious controversy as to the identity of that process or the nature of the phenomena encountered therein. The controversy has always been as to whether the patents charged to be infringed by this process were valid patents when construed so broadly as to be infringed by this process.

The "high-pressure coil cracker" or "Winkler-Koch" type of cracking process is simplified as compared to prior commercial processes in that the cracking portion of the system consists merely of a heating coil into one end of which the oil is forced under very high pressure. Upon emerging from the other end of this coil both the pressure and the temperature are reduced so that no significant cracking occurs thereafter.

In the usual installation of this type the heating coil is composed of a large number of serially connected tubes which are grouped in five banks. The first tube bank (i. e. the tube bank through which the oil first flows) functions merely as a preheater. It is located behind a fire-wall to shield it from the fire so that it is heated only by convection. In passing through this first tube bank the oil is merely brought to a temperature approaching that at which cracking begins, that is, a temperature on the order of 665° F. The oil then passes in succession through the second tube bank and the third tube bank. In passing through the second and third tube banks the oil temperature is raised to a value on the order of 911° F. The time required to pass through the second and third tube banks is on the order of 2.7 minutes (Appellant's App. 28-30). Accordingly, the large temperature increase while passing therethrough (from 665° to 911° F.) involves the application of a very high heating rate. This heating rate is much higher than that attained in the earlier tube and tank process where the heating coil was shielded from direct radiation. In the Winkler-Koch type of process this very high heating rate is maintained in the second and third tube banks (1) by positioning the second tube bank near the top of the bridge wall where the hottest gases will pass over it as they come over the top of the bridge wall and (2) by extending the third tube bank (the roof tubes) out over the fire box so that these tubes will not be shielded and will be heated primarily by direct radiation. The oil leaving the third tube bank then passes in succession

through the fourth and fifth tube banks both of which are shielded. In passing through the fourth and fifth tube banks the temperature of the oil increases to a value on the order of 926° F., or only about 15 degrees higher than the oil temperature at the outlet of the third tube bank.

In an operation typical of the Winkler-Koch type of process the oil enters the heating coil at a pressure on the order of 1150 pounds per square inch. The pressure on the oil progressively decreases as it travels through the coil due to frictional resistance, but by the time it reaches the outlet of the third tube banks the pressure on the hot oil still is on the order of 880-900 pounds per square inch. This pressure is well in excess of the critical pressure (Appellant's App. 32-33). Yet in this Winkler-Koch type of operation wherein the time required to pass through the second and third tube banks is only 2.7 minutes

“about 13 per cent of the stream has been cracked and about 15 per cent of the stream has been vaporized”

by the time it reaches the outlet of the third tube bank (Appellant's App. 101). In other words, about 85% of the oil remains in liquid state at this point. It does not vaporize completely even during its passage through the fourth and fifth tube banks notwithstanding a further increase in temperature (Appellant's App. 101).

In the Winkler-Koch or “high-pressure coil cracker” type of process the objectionable deposition of carbon or coke was eliminated substantially completely by virtue of the high velocity at which the oil travelled through the heating and cracking zones. As Smith pointed out (Appellant's App. 56-57) the Winkler-Koch stills frequently operate continuously for periods of longer than three months, this being the average length of operation, and even then the amount of deposited carbon is insignificant. However, aside from the fact that the cracking reaction

proceeds at a more rapid rate by virtue of the higher temperature employed, the cracking reaction in this type of process follows the same general pattern as in other prior art cracking processes in that tar, in large amounts, is produced as a by-product of the reaction. This low value by-product represents a substantial part of the ultimate products produced by a cracking process of this type (Appellant's App. 56-57).

The Winkler-Koch type of process employs a very high heating rate in the second and third tube banks in order to avoid the necessity of utilizing an unreasonably large portion of the heating coil to bring the oil to a temperature where the desired high reaction rate will prevail. It is worthy of note that in this Winkler-Koch type of operation the heating rate in the second and third banks of tubes could not be significantly further increased when employing heating tubes of the diameter conventionally used in commercial oil cracking equipment without overheating of the tubes (Appellant's App. 54).

The Prior Paper Art

Gard et al. patent No. 1,914,914 and Peck patent No. 1,933,507 were cited by the Examiner as examples of the prior paper art. To supplement these two paper patents, an article published by McKee & Parker, describing laboratory experiments conducted by the authors and drawing certain conclusions therefrom, also was cited.*

Both of the last-mentioned patents relate to processes the asserted objective of which is to eliminate or substantially reduce the formation of *carbon deposits* in the cracking zone of an oil cracking system. But each of these patents acknowledges that in the form of process therein dis-

*The Gard et al. patent and the Peck patent appear in Appellant's Appendix at pages 140-149 and 152-156. The McKee & Parker article appears at pages 157-160.

closed tar is formed as a by-product of the cracking reaction just as has always occurred in all prior cracking processes.

Gard et al. Patent No. 1,914,914

The Gard et al. patent was asserted by the Patent Office Board of Appeals to be the most pertinent prior art patent. It describes an oil cracking process in which the oil to be cracked is passed in succession through first and second serially-connected heating coils which are located in adjacent furnaces. In the described method of operation the oil is maintained under a pressure exceeding the critical pressure while passing through the first heating coil, and while passing through this first coil the oil is heated at least to its critical temperature. Upon passing from the first heating coil to the second heating coil the pressure is reduced almost to atmospheric pressure. In the preferred form of apparatus the first heating coil is of relatively large diameter as compared to the second.

This patent states that the objective of the process is to prevent deposition of carbon in the cracking zone, and that the conditions essential to prevention of such carbon deposits are that (1) no liquid shall enter the second coil and (2) that "high vapor velocity" shall be maintained in the second coil "to scour the tubes to remove from the tubes any deposited carbon".

Apparently relying upon a conclusion stated in the McKee & Parker article cited by the Examiner in this case,* this patent asserts:

"if the oil is heated under very high pressure to at least the critical temperature of the initial oil, it will be safe to *assume* that the oil when it reaches the tem-

*The formulae set forth in the Gard et al. patent are those developed in the McKee & Parker article, and the assumptions asserted in this patent conform with conclusions drawn by the authors of the McKee & Parker article.

perature found to be the critical temperature of the original oil, it will be entirely in the vapor phase.” (Appellant’s App. 145-146).*

However, the patentees regard the absence of liquid in the second coil as being of sufficient importance to warrant a large pressure reduction between the first coil and the second coil “in order to insure that no liquid enters the vapor phase cracking coils”.

This Gard et al. patent suggests heating the oil in the initial coil (coil 11 in Fig. 1; Appellant’s App. 140—see also Appellant’s App. 147, ls. 115-118) to a temperature on the order of 875° F. and then expanding into the second coil. In the second coil 17 the expanded vapor is heated to bring it to the desired cracking temperature described as “above 1000° F.” (Appellant’s App. 147, ls. 123-127). The patent recognizes that the expansion which occurs between the first and second coils normally will cause a considerable “temperature drop” (Appellant’s App. 147, ls. 79-83), and it is one of the described objects of the unusual tapered form of coil, illustrated in Figs. 3 and 5 of the patent, to permit mitigation of “the drop in temperature necessarily resulting on expansion” and thus increase the rate at which the expanded oil vapors in the *second* coil are brought to the desired temperature described as being 1000° F. and over (Appellant’s App. 148, ls. 34-44).

Except for the circumstance that one of the claims in this patent (claim 8) describes the Gard et al. process as comprising “rapidly heating oil in a flowing stream under a super-atmospheric pressure to the *critical* temperature of said oil”, there is no suggestion in the entire patent that the heating rate desired to be employed in the *first* of the two heating coils is to be of such a nature as to

*As we will later point out, this assumption does not conform with the facts established by the experiments conducted by Smith and by the conditions found to exist in the operations of the Winkler-Koch type of cracking process.

be characterizable as even moderately rapid, although, as above pointed out, the specification clearly describes and emphasizes the desire of the patentees to effect rapid heating of the expanded vapors in the *second* coil to offset the temperature drop that necessarily accompanies the expansion.

Of perhaps even greater significance is the fact that this patent discloses no reason for attempting to heat the oil at any particularly rapid rate while the oil is in the first or high pressure heating coil (Appellant's App. 51).

The witness Smith has testified (Appellant's App. 53-54) that the time factor in the first of the two successive coils in the process of this patent must necessarily be much longer in the first coil than in the second coil because of the high pressure in the first coil and the low pressure in the second coil, and he has further pointed out that because of this relationship of time factors, a very considerable part of the total conversion or cracking, described in the patent as being about 50% (Appellant's App. 147, ls. 123-128), would necessarily occur in the *first* of the heating coils of the Gard et al. process if the oil is actually heated to its *critical* temperature in the *first* heating coil. Smith pointed out that the critical temperature of oil of the type that is charged to cracking stills is far above the temperature at which cracking begins.

One of the features of novelty in the process of the Gard et al. patent resides in the fact that the oil vapors upon leaving the second coil 17 are immediately mixed with a relatively cool oil, the latter being supplied "in amount and temperatures sufficient to considerably cool the vapors and coalesce carbons or tars formed in the cracking" (Appellant's App. 148, ls. 1-6).

Peck Patent No. 1,933,507

The Peck patent has been acknowledged by the Patent Office Board of Appeals as being less pertinent than the patent to Gard et al. (Appellant's App. 76). This patent describes an oil cracking process in which oil is first heated in a coil under a pressure exceeding the critical pressure to a temperature exceeding the critical temperature. The heated oil is then discharged to a soaking chamber where substantial further cracking is permitted to take place in much the same manner as in the earlier tube and tank type of process. From the soaking chamber the cracked products are discharged into a tar separator and, as in the Gard et al. patent, Peck states:

"In order to insure the separation of the tar, cold feed, such as crude oil, gas oil, etc. may be introduced into the hot cracked product just before it is discharged into the tar separator. The cooling thus obtained will precipitate out the tar which must be removed from the system if excessive coke formation is to be avoided." (Appellant's App. 156, ls. 20-27).

This patent states that although a very large amount of cracking may occur before vaporization takes place, the oil will at all times be in a homogeneous state (i. e., either all liquid or all vapor) so long as the oil is heated to its critical temperature under a pressure in excess of its critical pressure *at a rate that is not exceptionally slow*. Thus, on page 3 of the patent (Appellant's App. 155) the Peck patent states:

"At 925° F. a 34° A.P.I. Mid Continent gas oil can be cracked to the maximum of its practical conversion limit, i. e. 40% gasoline in the homogeneous state under 900 lbs. sq. in. pressure (or higher) if the rate of heating the oil to that temperature is not exceptionally slow."

As a further indication of what the patentee means by a heating rate that is "not exceptionally slow", he describes on page 2 of the patent (Appellant's App. 154, ls. 121-140) an operation in which the oil is heated under a pressure of 750 lbs. per square inch until it reaches a temperature of 950° F. In his description of this exemplary operation the patentee states:

"Cracking will naturally take place during the time while the oil is heated up to 950° F.

"If the heating up is effected in a short time so that the cracking is below the conversion of 25% gasoline when the temperature of 850° F. is reached, the cracking will be homogeneous."

It will be quite apparent that a rate of heating permitting as much as 24% conversion *by the time the oil attains a temperature of 850° F.*, is a heating rate much slower than the heating rate employed in a typical commercial Winkler-Koch type operation wherein the oil attains a temperature on the order of 911° F. by the time 13% of the oil has been cracked (Appellant's App. 101).

Howard & Loomis Patent No. 1,869,337

The Howard & Loomis patent was not considered pertinent by either the Examiner or the Patent Office Board of Appeals, but was cited by the solicitor for the Patent Office at the trial of this case before the District Court.

This patent (Appellant's App. 112-116) relates to a process intended primarily to effect a reduction in the viscosity of heavy crude oils rather than to effect the conversion of higher boiling oils into lower boiling oils. However, it is of course true that even at the very low maximum temperature employed in the process of this patent (800° F.) the cracking reaction would inherently produce a very small amount of low boiling oils.

In the process of this patent the oil to be treated is initially preheated to a temperature on the order of 450°-550° F. and then forced in succession through the heating coils designated 10 and 15, respectively, in Fig. 1 of the patent drawing. Coils 10 and 15 are described in the patent as coils of 2 inch pipe 800 feet in length. The oil is described as passing therethrough at a rate of 500 gallons per hour. In passing through coil 10 the temperature of the oil is increased to a temperature approximating 725°-750° F. and this oil temperature is further increased to 800° F. during its passage through coil 15. The maximum temperature attained in the entire system is this temperature of 800° F. which is reached in coil 15. This temperature is far below the critical temperature of the oil being treated (Appellant's App. 45-46) and the patent states that the pressure maintained on the oil during its passage through both heating coils "is at least sufficient to maintain it substantially entirely in the liquid phase" (Appellant's App. 113).

Smith pointed out that the characteristic feature of the Howard & Loomis patent resides in the use of a very mild heating rate in heating the oil in the liquid state between about 725° F. and 800° F., this being described as an essential to avoidance of the formation of coke. All of this temperature range (725-800° F.) is well below the critical temperature of the oil. But it is high enough for cracking to occur. The portion of the heating thus specified by Howard & Loomis as requiring mild heating, in order to accomplish the objective there desired, falls squarely within the range over which an extremely rapid heating rate is required in the Smith process.

The Howard & Loomis patent points out that while the oil is merely being brought up to an active cracking temperature, in the initial coil 10, it is not necessary to employ the extremely mild heating that is employed in coil 15. Accordingly, it does not propose to limit the heating rate in coil 10 to the very low heating rate applied in coil 15.

Smith pointed out that in the operation described in the Howard & Loomis patent about 12 minutes are required for the oil to pass through the initial heating coil 10 (Appellant's App. 46). The described heating rate in coil 10 of the Howard & Loomis process is thus one producing a temperature rise of 300° F. (or less) in 12 minutes.* This represents a temperature rise of 25 degrees per minute. The Howard & Loomis patent characterizes the heating which occurs in coil 10 as *rapid* in order to contrast it with the extremely mild heating rate which occurs in coil 15. But it will be apparent that even the heating rate in coil 10 of Howard & Loomis is itself a *very mild heating rate* as compared to the heating rate employed in the second and third tube banks of the commercial Winkler-Koch type of cracking process wherein an average temperature rise of 82 degrees per minute prevails.

The Howard & Loomis patent does not purport to represent that, in the process therein disclosed, the cracking reaction will follow any pattern different from that followed by the cracking reaction in all prior cracking processes as regards the formation of tar as a by-product of the cracking reaction.

The McKee & Parker Article

The McKee & Parker article cited by the Examiner in this case (Appellant's App. 157-160) describes a considerable number of laboratory experiments made by the authors in a study of the critical temperatures and pressures of oil and their relationship to oil cracking. The article describes the procedure followed by the authors in making their experiments and points out certain respects

*Even when one takes the minimum temperature described at the inlet of coil 10 (450° F.) and the maximum temperature described at the outlet of coil 10 (750° F.), the temperature rise during passage through coil 10 is only 300° F. in the operation described in the Howard & Loomis patent.

in which the tests are subject to criticism. The article also sets forth certain conclusions that are *assumed to be* established by the tests described therein.

In the experiments there described the authors sealed small samples of liquid oil in glass tubes which were only partially filled by the samples, so that even at the beginning of the experiment a gas filled space remained above the liquid sample. This permitted observation of the meniscus at the upper surface of the liquid. Heat then was applied to the tube at such a rate as was "required to heat the tube from 375° C. [707° F.] to the critical point" in "9 minutes" (Appellant's App. 159). The sample was then cooled. When this procedure was followed it was noted that at a given temperature the meniscus disappeared when the temperature was rising and reappeared when the temperature was falling. The authors *assumed* that this temperature (or one slightly above it) at which the meniscus disappeared and reappeared under the test conditions, represented the critical temperature, and that the disappearance and reappearance of the meniscus established that no vaporization will occur until this critical temperature is attained. They concluded that these observations established that at this critical temperature instantaneous and complete vaporization will occur when the oil is heated at the pressure used in the test and with the heating rate used in the test. The tests made by the witness Smith and described in detail in his testimony (*post* pp. 20-23) have shown that these assumptions and conclusions were unfounded and not in accordance with the facts.

The authors of this article acknowledge that cracking occurred during the heating-up period, but, in view of their assumptions with respect to their tests, they concluded that the *only* effect of such cracking was to lower the apparent critical temperature "a few degrees lower than the true value of the starting material". Thus, the authors repre-

sent that, even with the 9 minute heating-up period employed in the test described in the article, complete and instantaneous vaporization will occur when the critical temperature is attained.

This article calls attention to the fact that the necessity of limiting the amount of oil in the testing tube so that initially it will only partially fill the tube, in the type of test there involved, does have a noticeable effect on the result of the test. It states: "Different values are obtained when different amounts of oil are used in the tube". This circumstance in itself shows the unreliability of this type of test. It will be noted that since the testing tube is not entirely filled with liquid oil in the type of test described in this article, the test cannot reproduce the conditions which prevail in the heating coil of a commercial cracking apparatus. In such apparatus that part of the heating coil adjacent its inlet is completely filled with liquid oil. No gas or vapor space exists until the oil itself begins to vaporize. The type of test employed by Smith was not subject to this criticism.

Smith's Tests and The Smith Invention

In 1936, Smith undertook to investigate the effect on the oil of the progressively changing conditions to which it is subjected as it passes through the heating coil in a cracking process of the Winkler-Koch type. In making this investigation Smith obtained a large sample of the oil that was currently being supplied to the inlet end of the heating coil in the commercial operation of a Winkler-Koch type still owned and operated by the Sinclair Refining Company. He then subjected small samples of this oil to a series of tests in an apparatus especially designed for this purpose. This apparatus is illustrated in the drawing that appears in appellant's appendix at page 133. Smith described this apparatus in detail as well as the

procedure followed and the phenomena observed in a series of these tests (Appellant's App. 35-45).

In Smith's test apparatus the oil sample to be tested was confined (by a liquid metal) in a small pyrex glass reaction tube having an internal diameter of 4 millimeters. The small sample of liquid oil thus confined was heated by an electric furnace provided with a glass window so that the sample being tested could be observed throughout the test. The heating capacity of the electric furnace was very high in proportion to the size of the sample being tested. The test apparatus was provided with a ram pump, arranged to apply any desired pressure to the sample being tested, and also with a rheostat for controlling the amount of current supplied to the electric furnace. This made it possible to vary at will both the pressure and temperature to which the sample was subjected.

Smith found that when the pressure and the heating effects applied to the small oil sample in his test apparatus were varied in such a way that the sample was subjected to the varying conditions progressively encountered by a given drop of oil as it passes through the heating coil of the commercial Winkler-Koch type of process, a point was reached at which the oil began to vaporize progressively and gradually *even though the pressure at this point exceeded the critical pressure*. He also found that this progressive vaporization continued but that a point at which the entire sample would be vaporized never was reached as there always remained a relatively small amount of tar containing liquid (Appellant's App. 37, 38, 40).

In both of these respects Smith's findings conformed with the conditions described in the opinion of the Court of Appeals in the Texas v. Anderson-Prichard case as prevailing in the Winkler-Koch operation charged with patent infringement in that strenuously contested case (Appellant's App. 101). Moreover, in both of these respects Smith's tests showed that conclusions based on the tests described in the McKee & Parker article were unreliable,

probably because of the faulty testing method. In particular they showed that McKee & Parker were *wrong* in concluding that vaporization will occur instantaneously and completely when the critical temperature is reached when the oil is heated at a pressure upwards of its critical pressure even when the heating rate is so low as to require 9 minutes to reach the critical temperature.

Smith testified that after making the tests just described, he made additional tests out of sheer curiosity. In these additional tests he utilized the very high heating capacity of the electric furnace in his test apparatus to heat the oil sample from a temperature in the neighborhood of 650° F. (at which no cracking occurs) to the critical temperature of the oil being tested (in this instance about 940° F.) in a period of less than 2 minutes. This involved the application of a heating rate considerably higher than even the very high heating rate which occurs in the second and third tube banks of the Winkler-Koch type of process*. It is a heating rate so high that it could not be applied to heating tubes of the relatively large diameter conventionally employed in commercial cracking processes without danger of burning the tubes (Appellant's App. 54).

To his surprise, Smith found that when this extremely high heating rate was applied to the oil while it is being held under a pressure in excess of its critical pressure, there was no *progressive* vaporization but that instead, upon reaching the point at which vaporization first began to occur, vaporization of the entire sample occurred instantaneously. He further found that the vapors thus formed could be maintained at a temperature as high or higher than that employed in the Winkler-Koch type of

*When this heating-up period is 2 minutes the average oil temperature rise per minute is 145° F. When the heating-up period is less than 2 minutes the heating rate is even higher. In the second and third tube banks in the Winkler-Koch type process, the average rate of temperature rise is about 82° F. per minute. It is only 25° F. in the initial heating coil of Howard & Loomis where the heating is described as rapid.

process for a prolonged period of time and a large amount of cracking thereby accomplished without any reappearance of liquid. He found that in such an operation no tar was discernible at any time (Appellant's App. 37-41). With this extremely high heating rate only a trace of cracking occurs before the critical temperature is reached.

Smith also identified four charts which appear in appellant's appendix at pages 134 to 137, inclusive. Smith testified that these charts show the results of four successive tests in his small test apparatus with heating rates varied to bring the oil from a temperature of 650° F. to the point of initial vaporization in periods of 1¼, 2, 3.6 and 4.55 minutes, respectively (Appellant's App. 38-41). Inspection of the first two of these charts clearly shows the instantaneous and complete character of the vaporization when heating to the point of initial vaporization was accomplished in periods of 1¼ minutes and 2 minutes, respectively (Appellant's App. 134-135). The third and fourth charts show the occurrence of progressive vaporization, that never reaches completion, when the time required to attain the point of initial vaporization appreciably exceeded 2 minutes (Appellant's App. 136-137).

Smith pointed out that the identification of the essentials of his process appearing in the decision of the Board of Appeals, and the statements by the Board (1) as to the temperature at which pitch formation occurs and (2) as to the procedure required to be followed to avoid pitch formation, did not conform with the facts. He pointed out that the *critical* temperature is a temperature considerably higher than that at which *cracking* begins (Appellant's App. 56). He also pointed out that the formation of pitch does *not* occur "at temperatures immediately below the *cracking* temperature" as the decision of the Board asserts (Appellant's App. 55, 74, 75). He also pointed out that in order to avoid pitch formation it is *not* necessary to bring the oil "quickly to the *cracking* tempera-

ture" as the Board asserted, and that such is *not a requirement of his process* (Appellant's App. 55, 74, 75). He pointed out that instead, the critical zone is that through which the oil passes *after* it has reached the temperature at which *cracking* begins but *before* it reaches the *critical* temperature which is considerably higher (Appellant's App. 56). Thus pitch formation can be avoided even though the oil is heated *very slowly* while bringing it *up to* the temperature at which *cracking* begins, so long as the oil is heated with extreme rapidity in raising its temperature *beyond* this point up to the *critical* temperature where vaporization then occurs when the pressure exceeds the critical pressure.

Smith acknowledged that even with the extremely high heating rate involved in his process and employed in his most rapid heating test, some cracking will inevitably occur before the point of vaporization is reached (Appellant's App. 47). However, he pointed out that the trace of cracking which must inevitably occur with this extremely high heating rate is *not* fatal to accomplishment of the objective of the Smith process in that it still was possible to continue the cracking for a prolonged period of time *after* the critical temperature had been attained without encountering any tar formation as was shown by his tests (Appellant's App. 38-41).

The Smith application here in issue describes the Smith process as one involving merely subjecting the oil to a sequence of specified conditions. Accordingly, this process is independent of the nature of the apparatus in which it is to be carried out. The form of apparatus may vary from the small laboratory apparatus used in the tests described by Smith on the one hand to the coil arrangement illustrated in the application drawing on the other. The application states (Appellant's App. 67):

"My invention * * * deals with the formation of pitch rather than with its consequences."

It adds (Appellant's App. 68):

"My invention avoids the original formation of pitch."

It describes the essentials of the invention in the following language (Appellant's App. 67):

"In carrying out my invention, I heat the higher boiling oil to vaporize it and thereafter heat it to crack it while maintaining a pressure exceeding the critical pressure on the oil through the point of vaporization, and I heat the oil prior to the point of vaporization at a rate high enough to prevent substantial decomposition prior to this point by limitation of the time factor."

The application acknowledges that the

"precise temperature, time and pressure used in any particular case will of course depend upon the stock being processed" (Appellant's App. 68),

but cites, as an example of the required heating rate, a particular application of the Smith process to the production of gasoline from Midcontinent gas oil. As applied to such a stock, suitable heating rates are described as being those capable of heating the oil

"to a temperature of 920°-980° F., from a temperature below that at which substantial decomposition begins, in from 1 to 2 minutes" (Appellant's App. 68).

At such extremely high heating rates only a trace of cracking can occur by the time the oil first reaches the critical temperature.

From the very beginning Smith recognized that the extremely rapid heating rate involved in his process was substantially higher than that prevailing in even the Winkler-

Koch type of process, and also that the heating rate in his process was in fact so high that any attempt to apply it in a commercial scale coil cracker having relatively large diameter tubes, such as are conventionally employed in commercial oil cracking apparatus, would involve serious danger of burning the tubes (Appellant's App. 54). Accordingly in his application he recommended that in a commercial scale apparatus that portion of the heating conduit in which the oil was to be raised with extreme rapidity to the critical temperature (illustrated as section 3 in the application drawing—Appellant's App. 71) should be composed of a group of tubes which were smaller in diameter than those incorporated in the subsequent heating section 4, the latter being of conventional construction. Tubes of small diameter have a higher ratio of heating surface to volume than do larger diameter tubes of equivalent volume. Accordingly, with small diameter tubes, very high heating rates can be employed before danger of burning the tubes is encountered (Appellant's App. 54).

Aside from this division of a portion of the heating conduit into a considerable number of heating tubes of relatively small diameter to permit an extremely high heating rate, the apparatus illustrated and described in the Smith application is essentially the same as the apparatus employed in the conventional Winkler-Koch type of still. Moreover, aside from the extremely high heating rate during the heating-up period, that is made practicable by this division of the heating conduit, the Smith process does not differ from the procedure in the conventional Winkler-Koch process.

The Decision of the Patent Office Board of Appeals

The decision of the Patent Office Board of Appeals (Appellant's App. 74-76) was rendered without knowledge of the tests performed by Smith and the unusual technical facts thereby established. It was rendered without knowledge of the fact that the meniscus type of test described in the McKee & Parker article is unreliable and without knowledge of the fact that the conclusions drawn by the authors of this article on the basis of the meniscus tests are not in accordance with the facts. Likewise the decision of the Board was rendered without the benefit of Smith's testimony as to the temperature at which tar formation occurs and the conditions required to be observed to prevent its formation. The Board also appears to have labored under the impression, shown by Smith's tests to be erroneous, that the formation of pitch cannot be *completely* avoided by the Smith process notwithstanding the impossibility of preventing a trace of decomposition.

As to each of these matters the decision of the Board of Appeals asserts a premise shown to be false by the evidence made available to the District Court but not available to the Patent Office Board of Appeals.

On the basis of the premises asserted in its decision, the Board concluded:

"We are of the opinion that in carrying out the operation defined in this patent, practically the same results will be obtained as with appellant's process. It is probable that in both cases some pitch will be formed during the liquid heating stage and the difference will be one of degree only." (Appellant's App. 75-76).

This conclusion naturally and properly follows from the recited premises upon which it is based. If it were true

that this conclusion accurately described the facts, then the Board would have been correct in affirming the Examiner. We submit that the error in the Board's decision arises from the error in asserted premises subsequently proven to be in conflict with the facts.

Rule of Law Involved.

The only rule of law involved in this case is a well established rule to the effect that when a new process or product differs from the prior art in a matter of degree (when considered solely from the standpoint of procedure or proportions), the difference is nevertheless one that warrants the granting of patent protection where the difference of degree is such that the new is separated from the old by a critical point beyond which a highly desirable new and unexpected result is obtained, or where the difference converts failure into success.

This rule is set forth in the decision of the United States Supreme Court in *Mineral Separation Limited, et al. v. Hyde*, 242 U. S. 261. It was restated and similarly applied by the Supreme Court in *Eibel Process Company v. Minnesota & Ontario Paper Company*, 261 U. S. 45. It has been applied by the Court of Appeals for the District of Columbia in *Becket v. Coe*, 69 App. D. C. 51, 98 F. (2d) 332.

Statement of Points

Appellant contends that the District Court's findings, numbered 8, 9 and 10, involve error. The errors here involved present two questions which must be determined here. They are:

1. Does the Smith process as defined in claims 1 and 2 involve a procedure that is *different from* or the *same as* the prior art?
2. Is the difference of a character that under the law warrants granting patent protection?

SUMMARY OF ARGUMENT

Point I

Appellant concedes that the Smith process as defined in claims 1 and 2 is not entitled to patent protection unless it involves novelty. The novelty lies in the extremely rapid heating rate at which the oil is heated under a pressure exceeding its critical pressure up to the point at which it reaches its critical temperature. In the claims this heating rate is defined as a rate high enough to "prevent substantial decomposition" in the period preceding attainment of the critical temperature.

As applied to the Howard & Loomis patent, to the Peck patent and to the prior practical art, determination of the question of novelty is simple because the Howard & Loomis patent and the Peck patent supply sufficient information to show that the heating-up rates employed therein are lower than that encountered in the commercial Winkler-Koch type of process wherein a conversion of 13% is attained during the heating-up period. Certainly it cannot be said that a heating rate which permits 13% conversion is one high enough to "prevent substantial decomposition".

Determination of the question of novelty with respect to the Gard et al. patent is more difficult but only because of the indefinite character of this patent. Examination of the face of the patent itself shows that it contains no definite disclosure of the extremely rapid heating-up rate that characterizes the Smith process, so that it becomes necessary to consider whether there is an implied disclosure.

Smith has pointed out that the described maintenance of (1) a very high pressure in Gard et al.'s first heating coil and (2) a low pressure in Gard et al.'s second heating coil, causes the oil to remain in the first heating coil for a *much longer period of time* than in the second heating coil due to the compressing effect of pressure. Therefore a considerable part of the total 50% conversion, de-

scribed as occurring in the Gard et al. process, must occur in the first or high pressure coil. Moreover, the patent emphasizes the rapidity of the heating in the *second or low pressure* coil in contrast to the rate of heating in the first or high pressure heating coil. It even recommends resorting to heating tubes of small diameter in the second or low pressure coil to permit the use of a high heating rate in this second heating coil.

It cannot be *implied* that Gard et al. employ, in their high pressure coil, the critically high heating rate characteristic of the Smith process merely because the Gard et al. patent states that only "incidental cracking" occurs during the high pressure heating-up period, or because it states that the oil is in the "liquid phase" while being heated to the critical temperature, or because it states that the oil may be *assumed* to be wholly in the vapor phase when the critical temperature is reached. These are merely statements of conditions assumed to exist on the basis of experiments similarly described in the patent and in the McKee & Parker article. The experiments described in the McKee & Parker article involved a heating-up period of 9 minutes and yet the same assumptions were made as to the conditions believed to prevail as those that are asserted in the Gard et al. patent. In these experimental operations the amount of "incidental cracking" which prevailed was, therefore, that amount of cracking which is *incident to* a 9 minute heating-up period. The commercial Winkler-Koch type of process shows that the amount of cracking incident to a heating-up period much shorter than 9 minutes (2.7 minutes) is very substantial (13%). Accordingly, in Gard et al. there is not even an implied disclosure of the critically high heating rate characteristic of Smith's process.

It is not reasonable to assume that Gard et al. unwittingly employed the critically high heating-up rate characteristic of the Smith process and that they merely failed to describe it in their patent, because if they had in fact

employed such a heating rate no tar would have formed in their process and the patent acknowledges that tar is formed. It is most unlikely that the revolutionary and highly desirable result (complete avoidance of tar formation) derived by the Smith process could have been obtained in the Gard et al. process and that the patentees merely continued to labor under the false impression that they were producing tar. Care should be taken not to read into the Gard et al. patent a disclosure not therein contained when examining the question of novelty.

Point II

Appellant acknowledges that the difference between the Smith process on the one hand, and on the other the prior paper art, exemplified by the Gard et al. patent, and the prior practical art, exemplified by Winkler-Koch, is one of degree when considered solely from the standpoint of manipulative procedure involved. However, the result flowing from the transition from the old to the new is different in kind from anything previously known or believed possible. It is as desirable as it was unexpected. The difference is one which causes modification or alteration of the cracking reaction so that it no longer produces tar-like material as a by-product.

The Smith process also avoids formation of coke, since initial formation of tar is a necessary incident to the subsequent production of coke. However, the modification of the cracking reaction which avoids tar formation in the Smith process is quite different in character from that which results in avoidance of coke formation in processes of the Winkler-Koch type, or in the type of process disclosed in the Gard et al. patent.

In Winkler-Koch and in Gard et al., coke formation is avoided by resorting to temperatures well in excess of 900° F. to obtain a very high reaction rate and then caus-

ing the oil to rush through the coil at high velocity so that the oil remains at the cracking temperature for a period of time shorter than that required to cause the further decomposition of tar to coke. But the Smith process does not involve a further overall reduction in the cracking period. In the Smith process no tar is discernible even when the material being treated remains at a temperature well in excess of 900° F. for a period of 8 minutes; this being longer than the total time required for the oil to pass through the entire heating coil in the commercial Winkler-Koch process.

Also in the Smith process avoidance of tar formation is not dependent on high velocity flow, since in the laboratory experiments described by Smith tar formation was avoided even when the oil remained substantially stationary in a small glass tube at a temperature well in excess of 900° F. for more than 8 minutes. Thus Smith's advance does not involve the mere carrying forward of an old idea with only such improvement in result as one would normally expect.

We think that application of the proper rule of law to the proven facts in the present case will require the conclusion that Smith's process as defined in claims 1 and 2 is entitled to patent protection.

ARGUMENT

Point I

Does the Smith process as defined in claims 1 and 2 involve a procedure that is different from or the same as the prior art?

Appellant acknowledges that if Smith's process as defined in claims 1 and 2 does not involve a procedure that is *different from* the prior art, appellant is not entitled to a patent containing these claims even though Smith was

the first to recognize that it is possible to crack without forming tar or pitch as a by-product of the cracking reaction, and even though Smith was the first to recognize and fully state the conditions essential to attainment of that objective. The eighth finding of the District Court implies that Smith's process incorporates the *same* procedure as that disclosed in the prior patents to Gard et al. and Peck when it states:

"it was not invention to adopt *the same procedure* to obviate or minimize the formation of pitch." (Emphasis ours).

The ninth finding of the District Court involves a similar implication, extended to include the Howard & Loomis patent, in reciting that

"The rate of heating the oil as recited in claims 1 and 2 here in issue differs only in degree, *if at all*, from the rates described as rapid in the prior art * * *." (Emphasis ours).

In considering this question it is appropriate first to note (1) the definition of the heating rate over the temperature range here critical and (2) the definition of the limits of the range over which this extremely high heating rate is to prevail, as these definitions appear in the claims in issue. At the outset it will be noted that the claims do not employ the term "rapid", or any term of such extreme ambiguity, to define the heating rate. Instead the claims first specify that during heating "*through the point of vaporization*" (claim 1) or "through the point at which it [the higher boiling oil] attains its *critical* temperature" (claim 2), there is to be maintained on the oil "a pressure exceeding the critical pressure". Both claims then specify that heating of the oil up to this point is to be effected "at a rate *high enough to prevent substantial decompo-*

sition" by the time this point [the critical temperature or the point of complete vaporization] is reached.

As applied to the Howard & Loomis patent, or to the Peck patent, or to the prior practical art, this simple question of novelty presents no difficulty. In the process of the Howard & Loomis patent both the initial and final heating stages, which collectively must include *all* of the decomposition, are carried to completion without bringing the oil to the point of complete vaporization or to the critical temperature. Even the final heating stage, which this patent characterizes as mild, is completed while the oil is maintained substantially in the liquid phase. Moreover, in the Howard & Loomis process even the initial heating stage, although characterized as *rapid* in this patent, involves such a low rate of temperature increase per unit time (at best 25° F. per minute) as compared to that encountered in the commercial Winkler-Koch type of process (about 82° F. per minute) that the former would necessarily permit a very large amount of cracking to occur by the time the critical temperature was attained if this heating rate were to be continued until the critical temperature was reached. The amount of conversion that would thereby result would obviously exceed by a large margin the 13% conversion which occurs in the Winkler-Koch type of process by the time the oil reaches the outlet of the third tube bank.

In the process of the Peck patent the proposed initial heating rate is one which will permit as much as 24% conversion by the time the oil attains a temperature of 850° F. Certainly this does not meet the requirement of the claims here in issue that the oil should be brought to the critical temperature at a rate which will "prevent substantial decomposition" before reaching the critical temperature.

As to the prior practical art, even the Winkler-Koch type of process which (in the second and third tube banks) incorporates the highest heating rate encountered in pres-

ent-day commercial cracking processes (a heating rate so high that any significant increase would involve danger of overheating the tubes) does not employ a heating rate high enough to bring the oil to the critical temperature without "substantial decomposition" since approximately 13% of the oil is cracked by the time the oil reaches the outlet of the third tube bank. At this point complete vaporization has not yet been obtained since about 85% of the oil still is in the liquid state at this point. But the pressure at this point is above the critical pressure.

The patent to Gard et al. presents a more serious difficulty. However, this is so largely because it is so indefinite and admittedly based upon so many assumptions.

This patent states that a very high pressure is maintained on the oil until it reaches the outlet of the first or high pressure heating coil, and that by the time the oil reaches the outlet of this first heating coil the oil has been heated at least to its critical temperature. However, the specification of this patent emphasizes only the importance of employing rapid heating in the *second* or low pressure coil and recommends the use of tubes of reduced diameter to promote this *rapid* heating in the *second* coil. The *specification* of this patent never refers to the heating rate in the *first* heating coil as being rapid nor does it use any language of similar import.

An implication that even in the *first* heating coil some heating rate characterizable as rapid was contemplated, arises from the manner in which the word "rapidly" is used in claim 8 of this patent. But there is no reason to assume that the rate of heating implied by this single usage of the word "rapidly" is any *more rapid* than the heating rate similarly described in the Howard & Loomis patent.

Nowhere does the Gard et al. patent state that no substantial decomposition occurs in the first or high pressure heating coil, and nowhere does it state that it is undesirable to have substantial decomposition in the first or high pressure coil. Nowhere does it state that the heating rate in

the high pressure coil should be high enough to prevent the occurrence of *substantial decomposition* before the oil attains its critical temperature. Nowhere does it state that the *incidental* occurrence of substantial decomposition in the first or high pressure coil would be in any way detrimental to accomplishment of the described objective of the process; namely, the attainment of the desired amount of conversion while avoiding the deposition of carbon; nor is such the case as is shown by the results obtained in the extensive commercial operations of the Winkler-Koch type of process.

On the other hand Smith has pointed out that in the process disclosed in the patent the time required for the oil to pass through the first or high pressure coil must be longer than the time required for the expanded oil vapors to pass through the second or low pressure coil due to the compressing effect of pressure. Smith also pointed out that with a total conversion of 50%, such as is described in the patent, a very considerable amount of conversion (representing a considerable proportion of the 50% total) would necessarily occur in that portion of the high pressure coil wherein the temperature was approaching the critical temperature because of the relationship of the time that the oil remains in this zone to the time that the oil remains in the low pressure coil. The described proposal to use tubes of smaller diameter in the *second* or low pressure coil than in the first or high pressure coil would in this respect be cumulative in effect.

Undoubtedly the portion of the Gard et al. patent which is most misleading and confusing is that part which starts with the last line of the first column on page 1 and continues through to about line 25 in the first column on page 2 (Appellant's App. 145-146). Here the patentees start by discussing the meniscus method of determining critical temperatures and pressures. They then set forth the formulae developed by the authors of the McKee & Parker article on the basis of the meniscus tests described in that article.

The patent then continues by reciting two conclusions which appear to be justified by the experiments and conclusions of McKee & Parker, but which have been shown by Smith's tests to be unwarranted and not in accordance with the facts. Thus the Gard et al. patent states:

"if the oil is heated under very high pressure to at least the critical temperature of the initial oil, it will be safe to assume that the oil when it reaches the temperature found to be the critical temperature of the original oil, it will be entirely in the vapor phase."

The patentees continue by stating that in their process the oil is heated "in *liquid phase* to the critical temperature" and they assert that this condition exists because of the very high pressure that is maintained on the oil while it is being heated to the critical temperature. In neither instance are the conditions here asserted to prevail, described as being conditions which prevail *only in the event that an extremely high heating rate is employed in bringing the oil to the critical temperature*. The patentees acknowledge that in bringing the oil to the cracking temperature "some incidental cracking" occurs and, like McKee & Parker, they acknowledge that such incidental cracking has the effect of lowering the critical temperature. However, the other asserted assumptions imply that "incidental cracking" even though substantial in amount does not preclude the occurrence of instantaneous and complete vaporization when the critical temperature is reached. In this respect the stated assumptions and implications of the Gard et al. patent parallel the conclusions of the McKee & Parker article, wherein disappearance of the meniscus was assumed to indicate instantaneous and complete vaporization even in those tests in which as much as 9 minutes had elapsed in the course of raising the oil to its critical temperature.

Accordingly, there is no reason to conclude that Gard et al. comprehended a heating rate in the *first* or high pressure heating coil *more rapid than the heating-up rates employed in the tests* described in the McKee & Parker article, much less a heating rate that is incomparably more rapid than the heating rates employed in the McKee & Parker tests.

Similarly, there is no reason to assume that the amount of decomposition comprehended by the expression "*incidental cracking*" in the Gard et al. patent is necessarily smaller than that which will occur *as an incident to a heating-up period extending over 9 minutes*, as in the tests described in the McKee & Parker article. That the "*incidental cracking*" which accompanies a 9 minute heating-up period is indeed substantial in amount is shown by the 13% conversion obtained in the heating-up period of only 2.7 minutes in the commercial Winkler-Koch cracking process.

We therefore submit that in the Gard et al. patent there is not even an implied disclosure of an oil cracking process in which the heating of the oil *up to* its critical temperature is effected under a pressure in excess of the critical pressure *and also at a heating rate high enough to "prevent substantial decomposition"* prior to the point at which the critical temperature is reached.

We also submit it is not reasonable to *assume* that Gard et al. unwittingly employed a heating-up rate high enough to prevent the occurrence of substantial decomposition before reaching the critical temperature and merely failed to describe employment of such a heating rate in their patent. We submit that this is not a reasonable assumption in view of the admission in the patent that tar and perhaps even carbon is formed in the process of this patent to such an extent as to require coalescing by the injection of cool oil upon discharge from the final heating coil. If the patentees had used the extremely high heating rate essential to compliance with the claims here in issue no tar would

have been formed in their process, and it is not reasonable to assume that this revolutionary and highly desirable result was in fact accomplished and yet remained unnoticed.

Where, as here, the difference in procedure is slight but the results flowing therefrom are revolutionary in character, great care should be taken not to *read into* a prior patent a disclosure that is not therein contained, when examining the question of novelty.

We submit that the Gard et al. patent contains no definite or implied disclosure of a process in which the oil to be cracked is heated to its critical temperature at a pressure in excess of its critical pressure *and at a rate high enough to "prevent substantial decomposition" prior to the time the critical temperature is reached.*

Point II

Is the difference between appellant's process and the prior art of a character that warrants patent protection?

The ninth and tenth findings by the District Court imply that even if the novelty of Smith's process as claimed is conceded, the difference between his process and the prior art is not one warranting the granting of patent protection. Appellant contends that the difference between the Smith process and the prior art is of such a character as to warrant the granting of patent protection.

Appellant acknowledges that the difference between Smith's process and prior processes, such as that of the Gard et al. patent on the one hand and the commercial Winkler-Koch process on the other, is one of degree when considered solely from the standpoint of manipulative procedure involved. But the result flowing from the transition from the old to the new is different in kind from anything previously known or believed possible. The involved difference in procedure has the effect of modifying

or altering the nature of the cracking reaction which occurs so that tar no longer is produced as a by-product even when cracking is continued over a period as long and even longer than the total cracking period employed in present-day commercial cracking processes of the Winkler-Koch type. This new result is as desirable as it is new and unexpected.

It is of course true that in the Smith process the formation of coke also is avoided, since initial formation of tar is a necessary incident to the subsequent production of coke. However, the modification of the cracking reaction which avoids tar formation in the Smith process is quite different in character from anything encountered in the Winkler-Koch type of process wherein the substantially complete elimination of coke already had been attained, or in the process of the Gard et al. patent which is similar in this respect. One is not a mere carrying forward of the other. The formation and deposition of coke was avoided in these prior art processes by (1) resorting to the use of temperatures well in excess of 900° F. so as to obtain a very rapid reaction rate, and then (2) causing the oil to rush through the coil at high velocity. By resorting to this procedure the total time during which the oil remained at the cracking temperature was reduced to a relatively short period as compared to the cracking period in early bulk distillation processes and processes of the tube and tank type. As a result of this reduced reaction period, the tar formed as a by-product of the cracking reaction did not remain at the cracking temperature for the prolonged periods which resulted in its further decomposition to carbon or coke.

However, in the Smith process avoidance of tar formation in the first instance is not accomplished by any further reduction of the duration of the total cracking period, for, as Smith pointed out, no discernible tar was formed in the tests performed by him even when the vaporized

oil was permitted to remain at an active cracking temperature for a period of time longer than that required for the oil to pass through the entire coil in the commercial Winkler-Koch type of process. This is well illustrated by the chart appearing in appellant's appendix at page 134. Here no liquid was formed even though the vaporized oil remained at a temperature well in excess of 900° F. for more than 8 minutes. In the Winkler-Koch type process the material undergoing treatment passes through the entire heating coil in a period substantially less than 8 minutes, yet tar is formed.

Moreover, in the Smith process this new result does not depend upon maintenance of high velocity flow, since in the laboratory tests performed by Smith the oil and vapors derived therefrom remained substantially stationary in a small glass tube for more than 8 minutes and yet no tar was formed.

Appellant acknowledges the general rule that when a new process or product differs from the prior art merely in degree as to procedure or proportions *and the new result also involves only a difference in degree*, the difference is not one which will warrant the granting of patent protection. In such cases the advance almost invariably involves merely the carrying forward of an old idea and therefore the difference frequently is aptly defined as a difference in degree *merely*. However, where, as here, a difference characterizable as a difference in degree is nevertheless productive of a new, unexpected and highly desirable result, it is equally well established that the difference is one which warrants the granting of patent protection as is shown by the decisions of the U. S. Supreme Court and the Court of Appeals for the District of Columbia cited on page 28 of this brief.

In the present case we think that the Patent Office Board of Appeals rested its decision wholly on its asserted belief that the difference between the Smith process and the proc-

ess described in the Gard et al. patent differed in *degree only* both as to the procedure involved *and as to the results flowing therefrom*. However, the evidence placed before the District Court shows, in our submission, that the new and highly desirable result flowing from the Smith process is different in kind from anything obtained in the processes of the prior art, and that this new and highly desirable result is not merely the obvious and expected result of simply carrying forward an old idea.

Conclusion

We respectfully urge that appellant is entitled to the relief requested in the complaint and that the decision of the District Court should be reversed.

CLARENCE M. FISHER,
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RAYMOND F. ADAMS,
LOUIS D. FORWARD,
Of Counsel.

UNITED STATES
COURT OF APPEALS FOR THE
DISTRICT OF COLUMBIA

FILED OCT 9 - 1942

Joseph W. Sturmer

CLERK

BRIEF FOR APPELLEE

**In the United States Court of Appeals
for the District of Columbia**

APPEAL NO. 8310

SINCLAIR REFINING COMPANY, APPELLANT

v.

CONWAY P. COE, COMMISSIONER OF PATENTS, APPELLEE

**APPEAL FROM THE JUDGMENT OF THE DISTRICT COURT OF THE
UNITED STATES FOR THE DISTRICT OF COLUMBIA**

W. W. COCHRAN,
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(I)

**In the United States Court of Appeals
for the District of Columbia**

APPEAL NO. 8310

SINCLAIR REFINING COMPANY, APPELLANT

v.

CONWAY P. COE, COMMISSIONER OF PATENTS, APPELLEE

***APPEAL FROM THE JUDGMENT OF THE DISTRICT COURT OF THE
UNITED STATES FOR THE DISTRICT OF COLUMBIA***

BRIEF FOR THE COMMISSIONER OF PATENTS

This is an appeal from the judgment (8)¹ of the District Court of the United States for the District of Columbia dismissing the Complaint (1) by which appellant, the assignee of the patent application No. 194,776, of Reading Barlow Smith, sought to have the lower court authorize the issuance of a patent on said application.

APPELLANT'S APPLICATION

The patent application here involved relates to a process of converting petroleum oils, such as gas oil having a high boiling point, into oils, such as gasoline having a low boiling point. The conversion is carried out by the reaction known as "cracking".

The process is clearly set forth in the only two claims made in the application. Claim 1 is typical and reads as follows:

1. The process of conversion of higher boiling petroleum oils to lower boiling oils which comprises heating the higher boiling oil to vaporize it and thereafter to crack it, maintaining a pressure exceeding the critical

¹The numbers in parenthesis throughout this brief refer to pages of appellant's appendix.

pressure on the oil through the point of vaporization and heating the oil prior to vaporization at a rate high enough to prevent substantial decomposition prior to vaporization.

It is claimed by appellant that by heating the oil at the high rate recited in the claims, the formation of pitch is prevented.

SUMMARY OF ARGUMENT

Each of the patents, Gard et al. (140), Peck (152), and Howard et al. (112) relates to a process which is in general the same as that claimed by appellant, that is, the conversion of high-boiling-point oils to low-boiling-point oils by cracking. According to each of the patents the oil is rapidly heated up to the cracking temperature while under great pressure. The pressures and temperatures in the Gard et al. and Peck processes are higher than the critical pressures and temperatures of the oil under treatment. One of the objects stated in each of the three patents is to eliminate or reduce the formation of carbon deposits or coke.

The rapid heating of the oil recited in the claims on appeal differs, if it differs at all, from the rapid heating disclosed in the prior patents, only in degree. Since the prior patents taught processes involving rapid heating, which processes resulted in eliminating or minimizing the formation of carbon deposits, it was not invention to heat the oil more rapidly to prevent entirely the formation of such deposits. This was only a carrying forward of the idea disclosed in the prior patents.

ARGUMENT

The Gard et al. patent

The Gard et al. patent, 1,914,914 (140-149) discloses an apparatus and method for cracking oil. The oil is first heated in the left-hand half of the furnace 12 (see Fig. 1) under a pressure above the critical to a temperature above the critical. This was admitted by appellant's witness (61). The rate of heating is described in claim 8 (148) as rapid. When the oil in the coil 11 reaches the critical temperature it is all vaporized. It is then released into the cracking coil 17 in the right-hand half

of the furnace where it is heated further and cracked (146, lines 5 to 25). The fact that all of the oil is vaporized in the first heating stage in coil 11 (coils 111 and 211 of Figs. 3 and 5) insures that no liquid oil enters the cracking coil 17, and this in turn according to the patent (145, lines 18 to 24) insures that no carbon deposit occurs. Apparently, however, these patentees did not expect complete success in preventing the formation of carbon deposits for they make reference (148, lines 5-6) to "carbons and tars formed in the cracking" It is clear, however, that the heating of the oil in the first phase in the coil 11 was not expected to cause much decomposition for according to the patent (147, lines 79 to 87),

The forms of furnaces here shown permit for the expansion of the gases gradually so that heat may be imparted to them as they expand, to compensate for the temperature drop. This also permits a rapid heating of the oil to its cracking temperature. This is desirable for a greater proportion of the gasoline formed is true vapor phase cracked gasoline.

From this statement it appears that the rapid heating in the coil 11 insures that the greater proportion of the cracking (decomposition) occurs in the cracking coil 17. This statement and the similar statement in claim 8 (148) would seem to link the rapid heating in coil 11 with the amount of decomposition of the oil in that coil.

The Peck Patent

The Peck patent, 1,933,507 (152-156) relates to the cracking of oil under such high temperature and pressure that the oil is in a homogenous state, that is to say, oil in the heating coil 1 and vessel 4 does not consist of a liquid portion and a vapor portion, but it is all in the state of a very dense vapor. This is the state of any fluid when it is at a temperature and pressure above the critical values for the fluid. There is no dispute as to the use by Peck of temperatures and pressures above the critical (61).

It is stated in the patent (154, lines 30-35) that coke formation is greatly reduced by keeping the oil in the homogenous state during the cracking. The patent also contains other state-

ments as to the suppression or elimination of the formation of coke (153, lines 9 to 11; 154, lines 49 to 51; 155, lines 143 to 146).

Peck does not propose to prevent decomposition of the oil entirely during the heating of it up to cracking temperature in the coil 1. He does, however (154, lines 133 to 136), state that the rate of heating is an important factor and then makes the following statement (154):

If the heating up is effected in a short time so that the cracking is below the conversion of 25% gasoline when the temperature of 850° F. is reached, the cracking will be homogeneous. However, if the heating is carried out at a slow rate and the oil is allowed to crack to 25% gasoline conversion at a time when the temperature reached is 850° F. or lower, separation into liquid and vapor phase takes place suddenly when the conditions of composition temperature and pressure are satisfied. This separation may vary from almost all liquid to almost all vapor within slight changes of any of the variables. In this case the cracking has not been carried out in the homogeneous phase and there is a danger of heavy coke deposition from the separated liquid phase.

This is a clear disclosure that by rapidly heating the oil up to cracking temperature, there is less decomposition and less formation of coke, than when the heating is done at a slow rate.

Peck did not apparently contemplate heating the oil up to cracking temperature rapidly enough to prevent all decomposition (cracking) of the oil but in the example given near the end of page 3 (155, beginning in line 133) the amount of decomposition was small and only traces of coke were formed.

While Peck did not carry the principle of rapidly heating the oil to decrease decomposition thereof and decrease the formation of tar or coke, to the ultimate point where there would be no decomposition at all, it is submitted that his patent teaches the principle.

THE HOWARD ET AL. PATENT

The patent to Howard et al. (112-116) discloses a method and apparatus for cracking oil in which the oil is heated in the

initial heating coil 10 to a cracking temperature and is later further heated in the cracking coil 15.

The patent contains the following statements (113, 114):

As the oil flows through the initial heating coil 10 the latter is fired hard in order to rapidly raise the temperature of the oil to a temperature at which conversion or cracking proceeds at a substantial rate, which temperature is above 650° F. and is preferably 725°-750° F., this temperature being acquired as the oil approaches the end of the initial heating coil. From the initial heating coil 10 the oil passes at once into the converting coil 15. This coil is fired slowly, the temperature rising only slightly to a higher cracking or conversion temperature of say 800° F. and being maintained there. During its travel through this coil the desired conversion of the oil is effected and local overheating of the coil is minimized.

* * * * *

It is found that by the procedure described, in which the oil is rapidly raised to a cracking temperature and subsequently its temperature slowly raised to and maintained at a high cracking temperature by slow firing, the production of coke is materially reduced or even substantially eliminated.

All of the claims of the patent recite the step of heating the oil in coil 10 rapidly up to cracking temperature, and it is clear that the patentees recognized the effect of rapid heating in reducing or eliminating the formation of coke.

APPELLANT'S CLAIMS

Claims 1 and 2 (2), on appeal, do not recite any specific rate at which the oil is heated and probably it would not have been practicable to recite a specific rate because of the differing characteristics of the oils to which the process is applied. The rate is recited as being high enough to prevent substantial decomposition prior to vaporization. None of the patents cited appears to disclose the use of a heating

rate high enough to eliminate entirely the decomposition of the oil, but it is submitted that the prior patents do clearly disclose the effect of rapid heating in reducing the decomposition of the oil, and thus reducing or even eliminating the formation of carbon deposits. The claims on appeal distinguish from the prior art merely in that they call for a sufficiently rapid heating to eliminate entirely, instead of partially as in the prior art, the decomposition of the oil. This is a mere carrying forward of the idea disclosed in the prior art and amounts only to a difference in degree in the result.

It does not appear that the authorities cited by appellant (Br. 28) support its argument as to the patentability of the appealed claims.

In *Minerals Separation Limited et al. v. Hyde*, 242 U. S. 261, the Supreme Court had under consideration a process of separating fine particles of metal from crushed ore, by mixing a minute quantity of oil with the ore and water and then beating air into the mixture to cause a froth carrying the metal particles to rise to the surface. The Court held this process patentable over the older practice of mixing oil in much larger quantity with powdered ore and water and allowing the oil loaded with metal particles to rise to the surface.

In *Eibel Process Co. v. Minnesota & Ontario Paper Co.*, 261 U. S. 45, the invention was in elevating the breast roll of a paper-making machine so as to make the wire cloth slope downwardly therefrom, and thus cause the liquid paper stock to flow along the wire cloth by gravity. In the prior practice the wire cloth had been disposed horizontally (or only slightly inclined for other purposes) and the paper stock was carried along by the wire cloth. The increased speed of travel of the liquid stock down the inclined wire cloth made it possible to increase the speed of the machine very greatly. Claims to the machine having the wire cloth thus inclined were held patentable.

The decision of this Court in *Becket v. Coe*, 98 F. (2d) 332, 69 App. D. C. 51, was that a certain iron base alloy was patentable because the proportions of the ingredients were critical for the production of an alloy which is stainless and capable of being deep drawn.

In all of these cases it is evident that the favorable decision on patentability was based on the fact that a new result was attained differing in kind and not just in degree from the results attained in the prior art.

In 1874, the Supreme Court in *Smith v. Nichols*, 21 Wall. 112, 119, announced the following rule which has been followed ever since:

* * * But a mere carrying forward or new or more extended application of the original thought, a change only in form, proportions, or degree, the substitution of equivalents, doing substantially the same thing in the same way by substantially the same means with better results, is not such invention as will sustain a patent.

CONCLUSION

It is submitted that the applicant Smith merely carried forward the thought disclosed in the prior patents of decreasing the decomposition of the oil during the heating thereof, and that this did not amount to invention.

It is therefore submitted that the judgment of the lower court should be affirmed.

W. W. COCHRAN,
Solicitor, U. S. Patent Office,
Attorney for Appellee.

OCTOBER 1942.

PETITION BY APPELLANT FOR REHEARING

IN THE
United States Court of Appeals
FOR THE DISTRICT OF COLUMBIA

No. 8310

SINCLAIR REFINING COMPANY,
Appellant,
vs.

CONWAY P. COE, Commissioner of Patents,
Appellee.

**Appeal From The District Court Of The United States
For The District Of Columbia**

Filed June 4, 1942

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IN THE
United States Court of Appeals
FOR THE DISTRICT OF COLUMBIA

No. 8310

SINCLAIR REFINING COMPANY,

Appellant,

vs.

CONWAY P. COE, COMMISSIONER OF PATENTS,

Appellee.

PETITION BY APPELLANT FOR REHEARING

Now comes appellant, Sinclair Refining Company, and respectfully petitions for rehearing in Case No. 8310.

Appellant feels that a rehearing is required because it believes that the findings of this Court, evidenced by two sentences appearing in the Court's opinion, indicate either

- (1) That the Court has labored under a misconception as to the manner in which the Smith process functions and the respect in which the new result thereby achieved differs from the results attainable by prior art methods and processes, or
- (2) That the Court has labored under a misconception as to the nature of the results which flow from prior improvements in methods and processes for cracking oil, this latter misconception being of a nature that bears directly on the question whether Smith's improvement does or does not involve a mere carrying forward or a more extended application or a mere maximum use of a previously known principle.

These two sentences in the opinion of the Court (p. 2) read as follows:

"The advantage of the Smith process, here involved, is the complete elimination of a *liquid residue* by complete vaporization of the oil, in contrast to a five or ten per cent residue in the Winkler-Koch process *and greater amounts in earlier processes.*" (Emphasis ours)

* * * * *

"The history of oil-cracking reveals steady progress in the improvement of methods and processes, *with the gradual cutting down of liquid residues* and elimination of carbons and cokes." (Emphasis ours)

In its opinion this Court seems to have used the term "liquid residue" as synonymous with "tar" or "pitch" although these terms may identify quite different products in the oil cracking industry. "Tar" or "pitch" is a product which, in all prior high pressure high temperature cracking processes, is *formed by* the same chemical reaction which produces gasoline. This tar or pitch is included in the liquid residues in those prior oil cracking processes, except to the extent that such tar or pitch may in some instances have been converted to carbon or coke by a *secondary* reaction. However, the *liquid residues* in many of these prior oil cracking processes normally include, *in addition to* the generated "tar" or "pitch", a large proportion of uncracked high boiling oil and may in fact consist largely of such uncracked high boiling oil.

A *liquid residue* normally is produced when carrying out the Smith process, such liquid residue being obtained when the products emerging from the cracking zone are cooled. However, this residue consists merely of high boiling oil that has escaped cracking. It does not contain "tar" or "pitch", because in the Smith process the nature of the *gasoline-producing chemical reaction* is such that

no "tar" or "pitch" is formed (Appellant's App. 40). Because it does not contain "tar" or "pitch", this liquid residue may be repeatedly repassed through the Smith cracking system to produce additional gasoline therefrom. The advantage of the Smith process is that it *does* produce gasoline *without* producing "tar" or "pitch". But complete elimination of a "liquid residue" is not an asserted or claimed advantage of the Smith process.

Unless the term "liquid residue" has been used as synonymous with "tar" or "pitch" in the opinion of the Court in this case, it therefore appears that the Court has labored under a misconception as to the identity of the Smith invention and the identity of the radically new result achieved thereby. But if, in the opinion of this Court, the term "liquid residue" *has been used as synonymous with tar or pitch*, it then appears that the Court has labored under a misconception as to the effects of the changes involved in prior improvements in methods and processes of cracking oil. In particular, it appears that the Court then has labored under the mistaken belief that the progressive improvements in high pressure high temperature oil cracking processes which have sometimes involved (as one of several factors) increases in the heating-up rate, and which have reduced and indeed substantially eliminated the formation of *carbon and coke*, have also produced *at least some decrease* in the amount of "tar" or "pitch" formed. It appears that this Court has labored under the mistaken belief that the amount of "tar" or "pitch" produced in the Winkler-Koch process is *less than* the amount of "tar" or "pitch" produced when earlier high pressure high temperature cracking processes were applied to comparable cracking stocks.

The prior patents and publications (Appellant's App. 112-116; 140-160), upon which appellee has relied for support of its contention that the *new result* achieved by the Smith process involves merely a *difference in degree* rather

than a difference in kind, do not purport to represent that an increase in the heating-up rate *or any other known factor* will reduce the amount of "tar" or "pitch" generated by the principal gasoline-producing chemical reaction (as distinguished from eliminating carbon or coke formation resulting from *secondary* reactions) *to a value one iota below the amount of tar or pitch formed by the principal gasoline-producing chemical reaction in the very earliest commercial high pressure high temperature cracking process*. Also the proponents of the progressively improved commercial high pressure high temperature oil cracking processes to which attention was directed at the trial of this case before the District Court (Appellant's App. 16-35; 77-132) have never represented that their processes produce *less "tar" or "pitch" than earlier oil cracking processes*, although admittedly the progressive developments have resulted at first in a reduction of, and finally in the substantially complete elimination of, *carbon and coke deposits*.

The evidence in this case, as distinguished from the oft repeated assertion of counsel for appellee, shows that the *amount of ultimately unvaporizable tar* which is formed during subsequent cracking with a heating-up rate such that vaporization begins in 3.60 minutes *is not less than* that formed during subsequent cracking with a heating-up rate such that vaporization begins in 4.55 minutes (Appellant's App. 136-137), but that with a heating-up rate such that vaporization begins (and is completed) in about 2 minutes or less the amount of ultimately unvaporizable tar is *zero* (Appellant's App. 134-135); *the same cracking stock being used in all instances*. The amount of ultimately unvaporizable tar is indicated in the charts comprising Plaintiff's Exhs. 16 and 17 (Appellant's App. 136-137) by the lowest point attained by the solid line in the volume charts at the left-hand side of these exhibits.

It is noted that the ultimate conclusion of the Patent Office Board of Appeals in this case to the effect that the

results achieved by the Smith process differed in degree rather than in kind, was assertedly predicated upon its belief (established to be erroneous by the proofs in this case) that the Smith process did not "completely avoid the formation of pitch" so that in both the Smith process and prior processes "some pitch will be formed" (Appellant's App. 75-76) rather than upon any presumption either (1) to the effect that progressive change in the heating-up rate *actually was a factor which progressively* alters the amount of tar or pitch formed by the principal gasoline-producing chemical reaction, or (2) to the effect that such change was believed by those skilled in the art (erroneously or otherwise) to be a factor having such an effect. On the other hand, the District Court appears to have predicated its ultimate decision largely on the belief that the Smith process actually embodied "the same procedure" as the prior art patents cited by the Patent Office (Appellant's App. 7-8; particularly findings 8 and 9).

If it be recognized that, even when oil is cracked at a temperature and pressure above the critical values, progressive increases in the heating-up rate *do not* produce progressive decreases in the amount of tar or pitch formation or even any decrease in tar or pitch formation, *unless and until the heating-up rate reaches a critically high value* whereupon the nature of the principal gasoline-producing reaction is changed so that *no* tar or pitch is formed, we think it will be apparent that Smith's contribution to the art does not involve merely the *maximum use* of a previously-known principle. Likewise, if it be recognized that, as in the Winkler-Koch process, the carbon problem already had been solved *completely in any practical sense* by merely preventing the *secondary* carbon-forming reactions, and that this result had been accomplished without employing the extremely high heating-up rate which is an essential characteristic of the Smith process, we think Smith's departure from prior practices will be recognized as not involving a natural step or natural development,

since it would seem to be unnatural and unreasonable to employ such an abnormally high heating-up rate for the purpose of eliminating carbon formation *that had already been eliminated* and in the absence of some reasonable basis for assuming that some *other and different* advantage might be thereby derived.

In view of what is set forth above, we respectfully urge that in justice to plaintiff, a rehearing should be granted in this case.

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Of Counsel

